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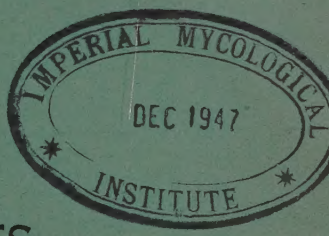


# NOTES ON STEM DISEASES OF TEA

## IN NORTH EAST INDIA

BY

A. C. TUNSTALL

AND

K. C. SARMAH

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*Dated 3rd July, 1947.*

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## INTRODUCTION.

Most of the losses associated with diseases of the woody branches of tea plants may be traced to pruning. The pruning, of necessity, exposes the woody tissues. When the large area of unprotected wood is taken into consideration, it is remarkable that infection by parasites is not much more prevalent.

It is probable that infection by true parasites such as *Nectria cinnabarina* does not usually occur after the sap on the cuts has dried up. The dried surfaces, which are of course dead tissue, do not as a rule begin to decay until a year or so after they have been exposed. It is then that weak parasites such as *Poria hypobrunnea* and *Glomerella major* begin to cause trouble. The progress of decay is however largely dependent on the condition of the branches concerned. Soft rapidly grown wood is more liable to decay than hard slowly grown wood. However the healing of wounds usually occurs more quickly on the rapidly grown wood. If the cuts heal over before decay is initiated no trouble occurs but when complete healing is delayed for more than one season decay sets in and may continue to progress long after the wound has healed over. This occurs more frequently in soft rapidly grown woody tissues than in the harder slowly grown ones.

Our observations have shown that the amount of dying back following severe pruning is to a great extent conditioned by the carbohydrate reserves present in the roots at the time of pruning. The reserves in a vigorously growing bush fluctuate more than those in a slow growing one. ***It is thus more important to so manage the plucking of good bushes prior to severe pruning to ensure that plenty of reserves are present when the pruning is carried out.*** This reduces the dying back to a minimum and ensures more rapid healing of wounds.

The position of the wounds relative to the main flow of sap also has an effect on both the tendency to die back and to the

subsequent decay of the tissues. ***Wounds low down on the inside of the frames are specially liable to cause trouble and so far as possible large ones should be avoided by removing unwanted branches while they are small.*** Branches arising low down on the inside of the frame almost always die back if cut below the general level of the pruning table.

In more recent years there has been a tendency to do the heavy pruning before the end of the period of rapid growth. This has introduced another cause of stem disease—sun-scorch.

Although it is impossible to prevent the dying back and the subsequent decay of some of the pruned branches experience has shown that a great deal can be avoided by paying attention to the points mentioned above.

In the following pages specific diseases are described. The space devoted to the description of individual diseases is no criterion of their relative importance.

It does not as a rule pay to treat rotting branches with a view to their recovery. It is cheaper and more satisfactory to cut them right out before the rot extends to the main frame. When the centre of the frame is rotten it is generally more economical to dig out and replace. Many bushes continue to flush satisfactorily after the whole of the centre has decayed away. It is therefore unnecessary to replace them until their flushing capacity is obviously reduced or their replacement fits into the programme of work.

Most of the pruning cuts on a bush in normal health heal quite satisfactorily without any special treatment. It is worth while protecting large wounds and all wounds so situated that healing is likely to be slow *e. g.*, in the centres of the frames, by painting them with bitumen paint. The paint requires to be renewed each year until healing is complete. A comparatively small amount of painting requires to be done. The long scars made by sun-scorch usually heal over quite satisfactorily without any specific treatment.

It is unwise to rely too much on generalisations as there is such a wide range of conditions. It is therefore desirable to examine each area in the light of local experience before making decisions.

CLASSIFICATION INDEX.

Features noticeable on the diseased stems with or without a lens.

The following notes may be found helpful in diagnosing some of the vegetable organisms on the stem of the tea plant. Some stem fungi do not produce auy external symptom, others are visible only with the help of a magnifying lens and a few develop characteristic symptoms visible to the naked eye.

***CHAPTER I.—Diseases initiated by vegetable parasites :—***

***(a) Attacks limited to the branches.***

*1.* ***Nectria cinnabarina***, page 12.

2. Thread blight, page 15.

*3.* ***Corticium salmonicolor***, page 17.

*4.* ***Loranthus*** sp., page 18.

1. Small pink cushions about $\frac{1}{32}''$ across or red spherical bodies, isolated or in groups, about $\frac{1}{120} - \frac{1}{60}$ inch across, usually produced in cracks, fissures and leaf scars—***Nectria cinnabarina***, (Tode) Fr. (see plate 1).

2. Distinct white, tough mycelial threads extending up to the undersides of the leaves—Thread blight (see plate 7, fig 4.)

3. (a) Silky white appearance, of the younger woody branches, which fades gradually and the surface becomes fibrous (b) pink crust, marked with cracks fromed at right angles to one another, usually on the shaded side of a stem. On older branches callus formation almost similar to that caused by sun-scorch but not confined to one side only—Pink disease, ***Corticium salmonicolor***, B & Br.

4. Clumps of parasitic growth, like mistletoe, with roots extending along the branches and firmly adhering to the latter and with leaves similar to those of China tea without the serrations—Roghumola, *Loranthus* spp.

(*b*) ***Attacks extending to and from the roots.***

*1.* ***Helicobasidium compactum***, page 19.

*2.* ***Ustulina zonata***, page 21.

*3.* ***Rosellinia arcuata***, page 21.

*4.* ***Hypoxylon asarcodes***, page 22.

1. Velvety pad of purplish-brown mycelium, about 2"—6" wide, encircling the main stem immediately above the soil level—***Helicobasidium compactum.*** Boedijn.

2. Black crust (charcoal-like when broken) produced on the main stem immediately above the collar. Also white fan-like felt of mycelium on the surface of the wood beneath the bark and black line at the edge of the fan—Charcoal stump rot (***Ustulina zonata***, Lev., Sacc.)

3. Loose stocking of dark grey mycelium covering the stem entirely to about 10 inches from the ground and groups of black spherical bodies produced on it at the base of the stem. These spherical bodies look like grains of shot. Also white star-like strands of mycelium on the surface of the wood beneath the bark—***Rosellinia arcuata***, Petch.

4. Hard, black, smooth crusts appearing as slightly raised patches of dried black paint on the main stem above the collar or on the branches up to about a foot from the soil level. Also canker on the stem similar to that produced by ***Macrophoma theicola***—***Hypoxylon asarcodes***, Theiss Mill.

***CHAPTER II.—Diseases associated with animal parasites :—***

1 Sooty moulds (*Capnodium* sp., *Limacinula theae* and *Meliola* Spp)., page 23.

2. *Aschersonia* sp., page 23.

3. *Septobasidium bogoriense*, page 24.

4. *Septobasidium* spp., page 25.

5. Rosette blight, page 65.

6. Canker (see abnormal callus growth), page 67.

1. Woolly or powdery, soot-like, dark grey to black mycelial growth often covering the stems entirely and also the upper surface of the green leaves—Sooty moulds (*Capnodium* sp., *Meliola* sp., and *Limacinula theae*)– see plate 2.

2. Isolated, hard, yellowish, orange or pinkish red cushions up to $\frac{1}{4}$ inch across, produced, on living stems attacked by scale insects and occasionally on green leaves – *Aschersonia* sp., (see pl. 3).

3. Bluish-grey continuous sheet of felt-like mycelium sometimes covering the entire stem and spreading to the under surface of the lower leaves, which are not injured—*Septobasidium bogoriense*, Pat. (pl. 4, fig. 1).

4. Velvety coating or felt, formed by mycelial growth on the stems, of any of the following colours *viz*., bluish, brown, yellowish-brown, purple-brown, reddish-brown, grey or black—Velvet blights, *Septobasidium* spp., (See pl. 4, figs. 2 & 3).

5 Shoots unusually thick at the top, internodes very short, leaves well proportioned but much smaller and closely situated—Rosette blight.

6. (a) Hard lumps or burrs with irregular surfaces (b) smooth woody galls (c) irregular swollen patches with cracks on the bark and (d) ring of raised, irregular, brown coloured growth encircling the stem of young plants about an inch above the soil surface (see plates 9—11).

***CHAPTER III.—Diseases associated with dead snags :—***

1. *Poria hypobrunnea*, page 26.

2. *Irpex destruens*, page 27.

3. *Auricularia Auricula-Judiae*, page 28.

4. *Fomes applanatus*, page 28.

5. „ *lucidus*, page 29.

6. „ *lignosus*, page 30.

7. *Aglaospora* sp., page 31.

8. *Massaria theicola*, page 32.

1. Yellowish to fawn coloured incrustation mostly formed on the underside of big branches (dead)—***Poria hypobrunnea*** (see plate 5.)

2. Thin, vertical, furrowed patches with thin horizontal brackets at the upper end, produced one above the other, at first dull white, then yellowish with a tinge of red, the brackets bearing radial ridges on the upper surface and tooth-like projections pointing downwards on the under surface—*Irpex destruens.*

3. Soft, small, gelatinous, brown brackets resembling human ears, produced on the stem just above the ground level or higher up —*Auricularia Auricula-Judiae* (L) Schr.

4. Thick, horizontal, brackets 3-12 inches across, upper surface zoned, grey and brown, with dull, polished, hard outer crust, under-surface yellowish white—*Fomes applanatus.*

5. Horizontal brackets about 2—24 inches across and ½—4 inches thick on jungle trees, smaller in size on tea, upper surface smooth and white at first, then yellowish red and finally deep red, shining as if varnished, sometimes zoned with white, yellow and red respectively from the margin towards the base—*Fomes lucidus.*

6. Small, horizontal brackets occurring singly or one above the other, semicircular, up to 3 inches across and up to ½ inch thick, upper surface red-brown with a zone of about ¼ inch of yellowish-red or orange-red at the margin, on drying marked with concentric, dark—brown, broad lines and narrow, radial striations, under surface deep orange—***Fomes lignosus***

7. No external symptom.

8. No external symptom.

***CHAPTER IV.--Diseases initiated by adverse climatic and cultural conditions :—***

1. Die-back (general), page 33.

2. *Macrophoma theicola*, page 39.

3. *Glomerella major*, page 40.

4. *Botryodiplodia theobromae*, page 41.

5. *Sphaerostilbe repens*, page 42.

6. *Corticium dealbans*, page 44

7. *Cephaleuros parasiticus*, page 45

8. Sun-scorch, page 50

9. Lightning, page 52.

10. Hail, page 53.

1. Self explanatory.

2. Patches of dead bark, surrounded by a succession of callus rings, formed on all sides of the branches. During the rains, the diseased bark, when scraped lightly with a knife may be found to be covered with minute cavities (pycnidia), either isolated or in groups, filled with a white substance—the spores in mass—***Macrophoma theicola.*** (see pl. 4, fig. 4).

3. No external symptom.

4. No external symptom.

5. Clusters of black, minute flower-bud-like structures, red at first, then black, produced at the collar or a little above it, occasionally at the base of the branches—Violet root rot—***Sphaerostilbe repens.***

6. (a) Bark of the young wood on living branches bleached white, and usually strips of brown primary cortex continue to adhere (b) pinkish patches ½—1½ inch by ⅛—⅜ inch formed below forks on younger brown twigs and on small dead twigs—White Corticium—***Corticium dealbans.*** (see pl. 7, figs. 2 & 3).

7. Purplish or slightly dark, somewhat swollen patches up to 1½ inch by ¾ inch, occasionally bearing longitudinal cracks on the surface during September to March. These patches and sometimes the whole length of a young stem covered with forests of tiny, orange red hairs during April to August. Leaves often variegated—Red rust, ***Cephaleuros parasiticus.***

8. Longitudinal cankers extending from the middle of the branches down to the soil level on the southern and the south western aspects of the bush, bark usually cracked and loose—Sun-scorch. (see pl. 8).

9. During the rainy season bushes suddenly die in a group, sometimes under a healthy shade tree—Lightning.

10. Cuts with sharp edges and bruises on the upper side of branches especially horizontal ones. Bark of the damaged lesions usually missing—Hail injury.

***CHAPTER V.—Diseases affecting the stems of seedlings :—***

1. *Phomopsis sp.*, page 54.
2. *Pythium sp.*, page 56.
3. *Rhizoctonia* sp., page 57.
4. *Gibberella* sp., page 57.
5. Heat injury, page 57.

1. The main stem of young seedlings, about an inch in length, a little above the soil surface is usually of smaller diameter than the adjoining portions. A ring of callus may be present at the upper edge of the diseased portion—*Phomopsis* sp., (see pl. 9, fig. 2).

2 Bark of the main stem of young seedlings, immediately above and or below the soil surface, soft and moist—*Pythium* sp.,

3. No external symptom.

4. No external symptom.

5. Formation of callus starting on the southern side of the main stem of young plants, covering one half to three fourths or the total circumference, from about 1—4 inches above the ground level—Heat injury. (see pl. 9, fig. 3).

***CHAPTER VI.—Organisms attacking dead tissue :—***

1. ***Aleurodiscus*** sp., page .
2. ***Stilbum nanum***, page .
3. ***Marasmius equicrinis***, page .
4. ***Nectria*** spp., page .

1. Small, chalky-white, almost round patches, $\frac{1}{8}$—$\frac{1}{4}$ inch across, with abruptly raised margin, produced on the dead primary cortex - ***Aleurodiscus*** sp., (see pl. 7, fig. 5).

2. Small, pinkish red,pin shaped projections, about 1-1$\frac{1}{2}$ m.m. high provided with a round, white top, produced in great numbers on dead twigs—***Stilbum nanum.***

3. Festoons of black, smooth, mycelial cords resembling horse-hair—Horse-hair blight, ***Marasmius equicrinis.***

4. Small, pink cushions $\frac{1}{32}$ inch across or red spherical bodies, isolated or in groups, about $\frac{1}{120}$ - $\frac{1}{60}$ inch across, proudced on pruning cuts, cracks and fissures etc., on the bark—*Nectria* Spp.

***CHAPTER VII.—Organisms grown on the surface—not known to penetrate living tissues :—***

1. White stem blight, page 61.

2. *Marasmius pulcher*, page 62

3. Algae, page 62.

4. Lichens, page 63.

5. Mosses, page 65.

1. One to three years old branches bleached white all over, lower green leaves sometimes yellowish, underside silky, dull white, surface of branches quite smooth, the primary cortex not retained—White stem blight. (see pl. 7, fig. 1).

2. Almost the same as Thread blight.

3. Greenish colouration of old tea stems in damp places —Algae.

4. (a) Dull white, light to dark grey, green, yellowish, brick-red, blue or greenish-black patches which appear as painted patches on the stem, often marked with various designs such as white or pinkish stars, dull-white, pinkish or black irregular spots, irregular black lines about $\frac{1}{8}$ inch long and black points or pinheads (b) thin, irregular, wrinkeld, greenish blue to ashy-grey leaf-like sheets, lobed and curled at the edges or (c) bunches of branched hairs, produced at intervals—Lichens.

***CHAPTER VIII.—Abnormalities :—***

1. Apple foliage blight, page 65.

2. Rosette blight, page 65.

3. Fasciation, page 66.

4. Zig-zag branching, page 66.

5. Abnormal callus growth, page 67.

1. Thin wiry shoots, rising fron one point on the branch, bearing miniature leaves that resemble apple leaves—Apple foliage blight.

2. (see page 5).

3. Green shoots flattened to about ½—1 inch.

4. Self explanatory.

5. (see page 5).

***CHAPTER IX.—Mycological Notes.***

## CHAPTER I.

### *Diseases initiated by vegetable parasites.*

#### (*a*) *Attacks limited to the branches.*

*Nectria cinnabarina* (Tode) Fr.

The fungus derives its specific name from the cinnabar red colour of one of its fructifications. It is a stem disease found in all the tea growing districts of North East India. Before the disease was thoroughly investigated most of the damage caused by the fungus to tea was attributed to other causes. In the Darjeeling district it occurred on tea frequently in the neighbourhood of certain trees, notably Utis (*Alnus nepalensis*) and Umphi (*Pyrularia edulis*). The unhealthy condition of the tea was attributed to some sort of poisoning effect associated with the above mentioned trees. In 1916, the unhealthy condition of the tea in Darjeeling was found, on closer investigation, to be caused by *Nectrina cinnabarina*. Due precautions are now taken and serious damage from the disease is much less frequent.

The fungus, as a rule, spreads from some centre of infection which is often some diseased branch of a shade or jungle tree. In such cases it is mostly found to occur on bushes on the wind-ward side of the tree in question.

At Tocklai, more than twenty years ago, a *Derris robusta* was artificially inoculated with ascospores of *Nectria cinnabarina* obtained from Darjeeling material. It is still alive and still infected. Smaller branches die back and a crop of fructifications is produced on the smaller twigs on those branches each successive year. On the main stem there is a rotting hole which has not extended for many years. Some longitudinal depressions present on the bark are the sole indication of the infection on the other portions of the main stem and on the larger branches. Tea branchs to the of north east of this tree are occasionally infected

but so long as the dying branches are cut out promptly the bushes continue to thrive. A few in which the dead and dying wood was allowed to remain died three or four years after infection.

A branch attacked by this disease becomes moribund at first, then gradually dies back until the fungus reaches the collar and spreads to other branches. Even then thin weakly shoots may be thrown out from below the obviously diseased portion but sooner or later these are also attacked and the bush of dies right out. Sometimes the bush dies branch by branch. The progress of the fungus is fairly slow and it takes a bush of average size about four years to die from the time of infection. The general appearance is similar to that of tea severely attacked by Red rust (*Cephaleuros parasiticus*). In a few cases the plants form callosities on the stems in an attempt to repair the damage done by the fungus. These however are not characteristic of this particular disease as they are caused by many agencies. Our investigations have shown that the fungus is a wound parasite; it is only capable of infecting through fresh wounds made by hail, pruning, cattle etc. The effect of the disease on tea bushes is comparatively easy to detect during the growing season—after the first flush. The diseased branches do not come away properly. A few miserable shoots may develop but these never catch up the rest of the new growth. On shade and other trees *Nectria* infection is rarely fatal. Branches die back year after year and fructifications are usually produced on the smaller twigs having thin bark. The fungus attacks the phloem of woody stems and the growing layers of cells (between the bark and the wood) and spreads thence through the medullary rays into the pith. The older woody tissue is not at first attacked but the fungus sometimes penetrates the walls of vessels and grows along them without causing any serious damage to those tissues. The injury to the host plants seems to be associated with the interference with transference of water from the wood to the phloem.

The fungus does not kill the growing layers at once but gradually starves the infected stems which become moribund and

after some months in that state frequently die. The fungus is generally present in the tissues of the plant some distance below the portion obviously diseased. On the death of the shoot, sometimes before, the fruiting stages are produced. These are easily found. They are produced on the bark of the stems. The most noticeable are pink cushions about $\frac{1}{32}$ of an inch across which are usually produced in profusion (see pl. 1, C and C1.) These consist of a mass of fungal hyphae or threads arranged together with their ends outwards. The end of each hypha swells slightly and a wall grows beneath the swelling. The swollen end then becomes detached, forming a spore. These spores are called conidiospores, and the cushions in which they are borne conidiophores (see pl. 12, fig. 2). Along with the conidiospores another form of fructification is produced—a number of dark (cinnabar) red spherical bodies of about $\frac{1}{120} - \frac{1}{60}$ inch across. These are produced singly or in groups, sometimes attached to the conidiophores, but more often separately (see pl. 1—P). Examination of these with a lens shows that they have a small cone-shaped aperture. The cone-shaped portion collapses slightly in old ones. A more careful examination with a microscope reveals that these bodies are often protected by hairy out-growths sometimes minutely roughened (see pl. 12, fig. 1). The production of these hairy projections appear to be controlled by climatic conditions. They are usually absent on the specimens from the plains. The spherical bodies contain a large number of sausage-shaped sacs each containing eight two-celled spores (see pl. 12, fig. 3 and 4).

Still another form of spore is produced. These spores are long, narrow, several celled and are known as fusarium spores, owing to their curved shape (see pl. 12, fig. 6). They are sometimes found on loose tufts of hyphae round about the perithecia and conidiophores.

On a few specimens, star-like markings, caused by the mycelium of the fungus were found, on the surface of the wood, when the bark was peeled off but it cannot be regarded as characteristic of the disease as this is unusual.

**Nectria cinnabarina** (Tode) Fr. on a tea stem. (C) Pink cushions of conidial fructification; (C1) the same highly magnified; (P) red perithecia; (L) patches of lichen.

TREATMENT.—This disease may be controlled by systematic removal of the infected material. It is necessary to search for trees known to harbour this disease in the neighourhood, especially in the direction of the prevailing winds. All moribund and dead branches on these should be removed before pruning the bushes. The cuts should be washed with strong Lime sulphur solution after they are made and then painted with bitumen paint.

Before the general pruning commences the diseased bushes should be pruned to clean healthy wood cutting away a good portion of the latter to ensure complete removal of the fungus which is sometimes present in the wood a few inches beyond the apparently diseased area. They should be sprayed with Lime sulphur solution immediately after pruning to prevent re-infection and then the larger cuts should be painted with bitumen paint. It is necessary to repaint the larger cuts at each pruning until they heal up completely.

The prunings of the diseased bushes should all be burned on the spot promptly.

Note :—The original description of dark red spherical bodies about $\frac{1}{40}$—$\frac{1}{50}$ inch across (given in "A Stem Disease of Tea" caused *by Nectria cinnabarina*, (Tode) Fr., 1918) was an error.

## THREAD BLIGHT.

The fungus derives its name from the white, thread-like appearance of the mycelial strands. It has no scientific name as its fructification has never been found. It is very common in all the tea growing districts of North East India. The invasion of the fungus is not confined to tea alone ; it is found on a number of other shrubs and trees. Although the outward appearance of all the Thread blights occurring on different hosts is same it has not been proved so far by any scientific observer that all these Thread blights are one and the same fungus. It has been observed that Thread blight on some other hosts at least are capable of attacking tea and vice versa. It is not uncommon to find the tea Thread blight attacking grasses and herbs when they come in contact

with diseased material. Thread blight on tea is not restricted to the stems it also attacks the green portions. It is only easy to detect when its damage on the leaves becomes severe.

The bnsh affected by this disease presents a similar appearance to that caused by Black rot *(Corticium invisum)*. The infecting material, which are small white cushions of fungal hyphae or bits of mycelial strands, lie hidden in the cracks and crevices of the older stems. Along with the beginning of the new growth the fungus commences to grow upwards along the stems, forming white, tough threads, (see pl. 7, fig. 4). By the time the bush is in full leaf these threads reach the new leaves and spread out to form a white felt on their under surface. After some time the affected leaves wither, turn brown and instead of dropping off, hang unto the stems, held by the white mycelial strands. Wherever the diseased leaves or stems come in contact with healthy ones the fungus spreads to the latter. It thrives best and spreads very quickly in damp shady places. The mycelial threads can be easily peeled off from the green portions of the bush when wet as the fungus is wholly external. It may be found throughout the year on old unpruned stems.

The fungus has not been observed to penetrate the living tissues, but mycelium was found in the external tissues of the old stems just outside the cork layer and especially in the original mechanical tissue outside the phloem element which is dead and functionless. Some observers, in other parts of India, have found the fungus penetrating the living tissues of the bark. But the writers have not so far observed the fungus in the living cells underneath the cork layer. It forms characteristic, pouch-like, swollen cells which are anchor-like in appearance and are known as anchor cells. These serve as a device for holding fast the fungus to the host plant. It also develops, on the leaves, a layer of hyphae covered with numerous short branches. It is believed that the fungus is capable of deriving its nourishment through the cell walls—probably by osmosis, but the exact procedure has not been worked out.

TREATMENT.— It is necessary to treat this disease in the growing season. Cold weather treatment has not been found very effective. The diseased bushes should be flagged at the time of plucking and sprayed thoroughly on the following day with 1% Burgundy mixture or 0·25%. Perenox (a preparation of copper sold by the Imperial Chemical Industries). Care should be taken to wet the stems and the undersides of the leaves thoroughly with the spray fluid. The spraying should be repeated a second time if the new growth shows signs of infection.

In special circumstances when only a few individuals are attacked it may be advantageous to pull off as much of the diseased material as possible before spraying.

### *Corticium salmonicolor* (B & Br.)

Pink disease.

This disease is present in the tea districts of North East India but is uncommon on tea. It does not do much damage to the tea as it requires special conditions not usually present on tea gardens in North East India. It has been observed on tea bushes growing on the northern slopes in narrow valleys in Cachar and Sylhet.

Branches attacked by this fungus appear silky white at first owing to the thin film of hyphae spreading on the surface. The mycelial threads are very fine and escape notice unless the stem is examined very closely. Usually the disease is seen on the younger woody branches, the surface of which becomes shiny to some extent at first, later on it becomes fibrous and the silky appearance gradually fades away. The fungus kills the bark in patches and although it sometimes penetrates to the woody tissues the branches concerned are rarely killed right out. The dead bark persists for a long time. As the growth of the healthy portions of the branch progresses the diseased patches become sunken. The diseased patches may be healed up completely by callus formation on vigorous bushes. On older branches

the fungus kills longitudinal, narrow patches of bark, which are surrounded by a slightly raised, thin ring of callus. Where the diseased patches are not healed up completely, other wood destroying fungi invade the dead tissues and cause them to rot—thus forming a hollow channel down the branch very similar to that caused by sun-scorch but not confined to any particular aspect of the bushes.

The fructification of the fungus appears as a pink patch usually on the shaded side of the stem and it is from this pink crust the fungus derives its name 'Pink disease'. The pink patch is often marked with cracks formed at right angles to one another. The spores of the fungus are produced free on the pink crust.

The fungus is not uncommon on woody plants growing in deep shade in the jungle.

TREATMENT.—The branches should be cut out below the obviously diseased portion of the bushes and the remaining portions sprayed with 1% Burgundy mixture or 0·5% Perenox. The prunings of infected bushes should be burned on the spot.

### *Loranthus* Spp.

### "Roghumola".

In the forests of North East India one frequently sees clumps of branches resembling mistletoe growing on the trees. These are also found on the tea plant particularly in the seed gardens. These clumps are, like the mistletoe, a parasitic growth. There are at least two species on tea in North East India. The parasites concerned are found everywhere in the tea districts but only cause damage when neglected. They are rare on plucking bushes. The roots of the Roghumola extend for a long way along the branches below the point at which its leaves and stems show themselves. The roots firmly adhere to the branches by means of rootlets which penetrate into the tissues. Various interesting things regarding this plant have been found out. It is believed by some people that the seeds do not germinate unless they have passed through a bird's intestines.

The leaves of the Roghumola are modified by the nature of the host plant. If the parasite is growing on a tree which bears narrow leaves its own leaves grow narrow. When growing on a broad leafed tree they grow broad, the shape of the leaves is even modified by the jat of the tea plant on which the parasite happens to be growing. On some jungle trees Roghumola has been seen to replace the whole of the normal foliage but when this happens both the host and the parasite die within a few years.

TREATMENT.—It may be removed by cutting off the infected branches. It is necessary to trace the haustoria within the branches and remove them by cutting out the affected portions. Any seeds sticking to the branches of the host plant should be removed.

*(b) Attacks extending to and from the roots.*

*Helicobasidium compactum* (Boedijn).

This fungus is occasionally seen, as a compact velvety pad of purplish-brown mycelium, on the stem of tea plants, especially young ones less than five years of age. Its occurrence on mature old tea bushes is rare. Although the thick pad of fungus always grows on the stem just above the soil level extending up to several inches it is not a stem disease. Unlike *Septobasidium* spp., it is a true parasite which attacks the roots. A short description and an illustration of this disease has already been published in the Indian Tea Association Memorandum No. 8.

This fuugus has also been observed on Boga medeloa (*Tephrosia candida*).

TREATMENT.—The treatment suggested for primary root diseases in I. T. A. Memorandum No. 8—Notes on Root Diseases of Tea—is applicable to this disease. It is repeated below.

*Isolation trench no longer recommended.*—More than fifty years ago the foresters in Europe sought to prevent root disease spreading by encircling the diseased trees with shallow trenches. This method was adopted in the case of rubber, tea and coffee. In North East

India we recommended that a trench be dug deep enough to prevent the roots of bushes on opposite sides from growing into contact. It was further suggested that a complete ring of apparently healthy bushes be enclosed within the trench. Observations on the progress of such diseases showed that a bush may be infected for many years before it dies or even shows obvious signs of sickness. The trench is often filled in long before the danger of a further extension of the disease is past. In certain cases digging of an isolating trench is still recommended but is usually unnecessary if the recommendations given below are carried out carefully.

*Soil disinfection not recommended.*—The application of quicklime to the soil whence a diseased tree had been removed was also commonly made in Europe. Research work on the fungi concerned showed that an alkaline medium was unfavourable to their growth. An improvement on the addition of lime alone was made in Java. By watering the limed soil with sulphate of ammonia free ammonia gas was set free in the soil. The application of Iron sulphate, Zinc sulphate and Copper sulphate solutions was also advocated. All of these chemical treatments would hinder the growth of the fungus mycelium wherever they came into contact with it. Observations extending over many years have failed to show that the mycelium of these fungi is capable of extending through the soil except in or near pieces of dead wood or collections of rotting vegetable matter. As chemicals applied to the soil are not likely to penetrate pieces of dead wood, their value in preventing the spread of the root disease fungus is doubtful and such applications are no longer recommended in North East India.

*The removal of infected material, the only reliable treatment.* It has been found that the careful removal of all dead wood from the soil in the vicinity of the diseased bushes is sufficient to prevent further extension of the disease concerned. As a further safeguard it is recommended that wherever diseased roots are found to be very close to the roots of a neighbouring apparently healthy bush the latter should be removed. Where an apparently healthy root of a shade tree or jungle tree is found to be close to the diseased root it should

be traced out for 3 or 4 feet in each direction and removed. The cut end attached to the tree should be washed with an antiseptic such as Lime sulphur solution and painted with bitumen paint before it is covered up with soil. Should the root of the shade or jungle tree appear to be diseased, the diseased portion should be traced right out and removed including 3 or 4 feet of apparently healthy root. The cut end attached to the living tree should be treated as described above. The roots and other wood removed from the soil should be burned. If all the infected material be removed in this way no further trouble is likely to be experienced and no other precautions are necessary. Good supervision is however essential to the proper carrying out of such work.

### *Ustulina zonata* (Lev.) Sacc.

Charcoal stump rot.

This is one of the commonest root diseases and it is found in all the districts of North East India on a number of plants including tea. The fungus not only attacks tea bushes through the roots by contact with diseased material but also infects them through the stems. It produces its fructifications—black, charcoal-like crusts—on the main stem. Descriptions and illustration of the fungus have been published in I. T. A. Memorandum No. 8. "Notes on Root Diseases of Tea."

TREATMENT.—See page 19.

### *Rosellinia arcuata* (Petch).

Black root-rot.

This is a root disease parasitic on tea and several other plants in all the districts of North East India. It is more common in the hill districts, than on the plains. The fungus derives its name from the black mycelial strands which grow on the surface of the roots giving them a black appearance. These strands can extend over the surface of the soil very rapidly. The characteristics and illustration of the fungus have been published in I. T. A. Memorandum No. 8 "Notes on Root Diseases of Tea".

The fructifications of the fungus are produced on the stems. These are of two kinds. First, a free type of spores is produced on a grey velvety stocking of mycelium which covers the stems entirely to a disatance of about 6 to 10 inches from the ground. The second type is produced in groups of spherical receptacles (perithecia) which look like grains of shot and are about $\frac{1}{10}$ inch in diameter, usually at the base of the branches.

TREATMENT.—See page 19.

### *Hypoxylon asarcodes* (Theiss) Mill.

So far this fungus has only been found on a few specimens of tea bushes from Jalpaiguri district and the Assam Valley. It is a root disease of rare occurrence. The fuugus is however a true parasite.

It does not produce any external mycelium so it is most likely that it infects tea bushes through the stems. The wood of the root attacked by this disease forms brown reticulations, as in Brown root rot but they are much smaller. Black lines similar to those produced by *Ustulina zonata* are sometimes present. The fructification of the fungus appears as hard, black, thin crusts on the stem. These crusts containing numerous black cavities (perithecia) look like patches of dried black paint and are sometimes produced as high up on the stems as 13 inches from the ground. The fungus produces a canker on the stem similar to that produced by *Macrophoma theicola*.

Illustrations and measurements have been published in I.T.A. Memorandum No. 8—"Notes on Root Diseases."

TREATMENT.—See page 19.

Sooty mould.

# CHAPTER II

## *Diseases associated with animal parasites.*

### *Capnodium* Sp., *Meliola* Sp., and *Limacinula theae.*

(Sooty moulds).

The name Sooty mould is derived from the soot-like appearance presented by the dark grey to black, woolly or powdery growth of mycelium on the stems and leaves. On the leaves the mycelium grows as a thin film which, when dry, peels off. On the stems the growth is either woolly or powdery and in most cases covers the stems entirely (see pl. 2). There are a number of fungi which produce this appearance. Macroscopically all of them are so similar that without the aid of a microscope it is impossible to distinguish them. These fungi are entirely superficial, growing on the sugary secretions ("honey-dew") of various insects. None of the fungi have so far been found to parasitise the tea bush. The only harm done to the tea bush is by shading the green portions and thus interfering with the absorption of light.

The fungi are present in all tea districts of North East India. They are found on numerous other plants besides tea but their presence is always associated with insects.

There is one fungus known as *Asterina camelliae* (Black blight) which is almost similar in appearance to the above but this is only found on the leaves of tea.

TREATMENT.—A single application of any fungicide is sufficient to kill the fungi but this is hardly necessary as they will disappear soon after the removal of the harbouring places of the insects. If the insects are not got rid of the fungi may return again after the spray fluid has disappeared.

### *Aschersonia* sp.

This is one of the insectivorous fungi found on tea in all districts. It grows in isolated, hard, yellowish, orange or pinkish

red cushions which are up to ¼ inch across. This fungus does not develop either mycelial felts or woolly growth on the stem. The cushions are sometimes confused with the pinkish or red ones of *Nectria* but the latter are much smaller, more even in colour and very soft in texture. Although the red fructifications of *Nectria* may be produced in clusters, they are less prominent than *Aschersonia* cushions. The fructifications of ***Nectria*** are found only on the stems while those of ***Aschersonia*** are not infreqently found on leaves as well (see Pl. 3). This fungus is to some extent beneficial to plants as it preys on insect parasites. It does not attack the tea bush.

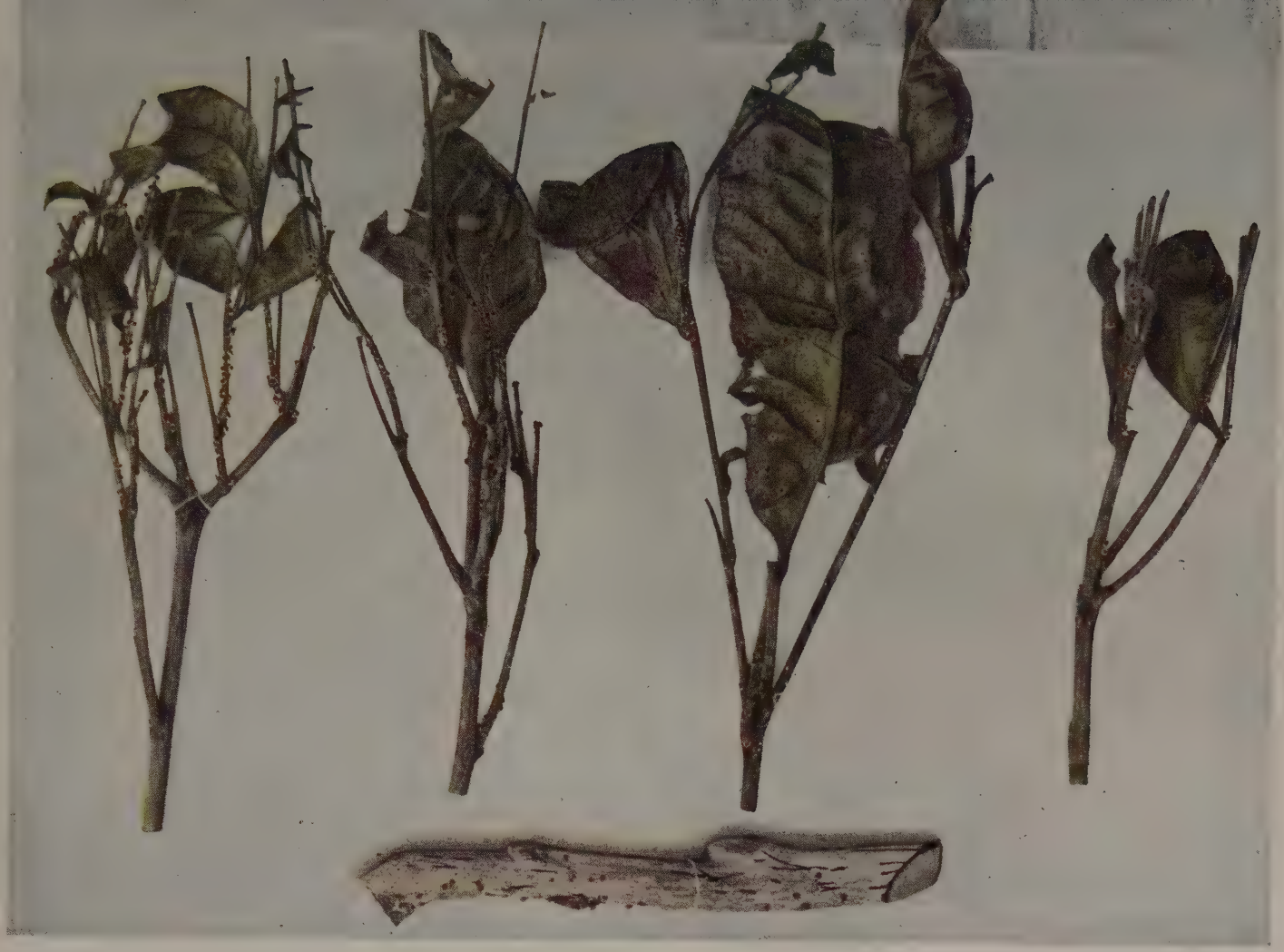
Besides tea it may be found on many plants attacked by insect parasites.

TREATMENT.—The only effective way of treating this fungus is to treat the bushes for scale insects. It is usually unnecessary as where this fungus is prevalent the scale insects rarely do much damage.

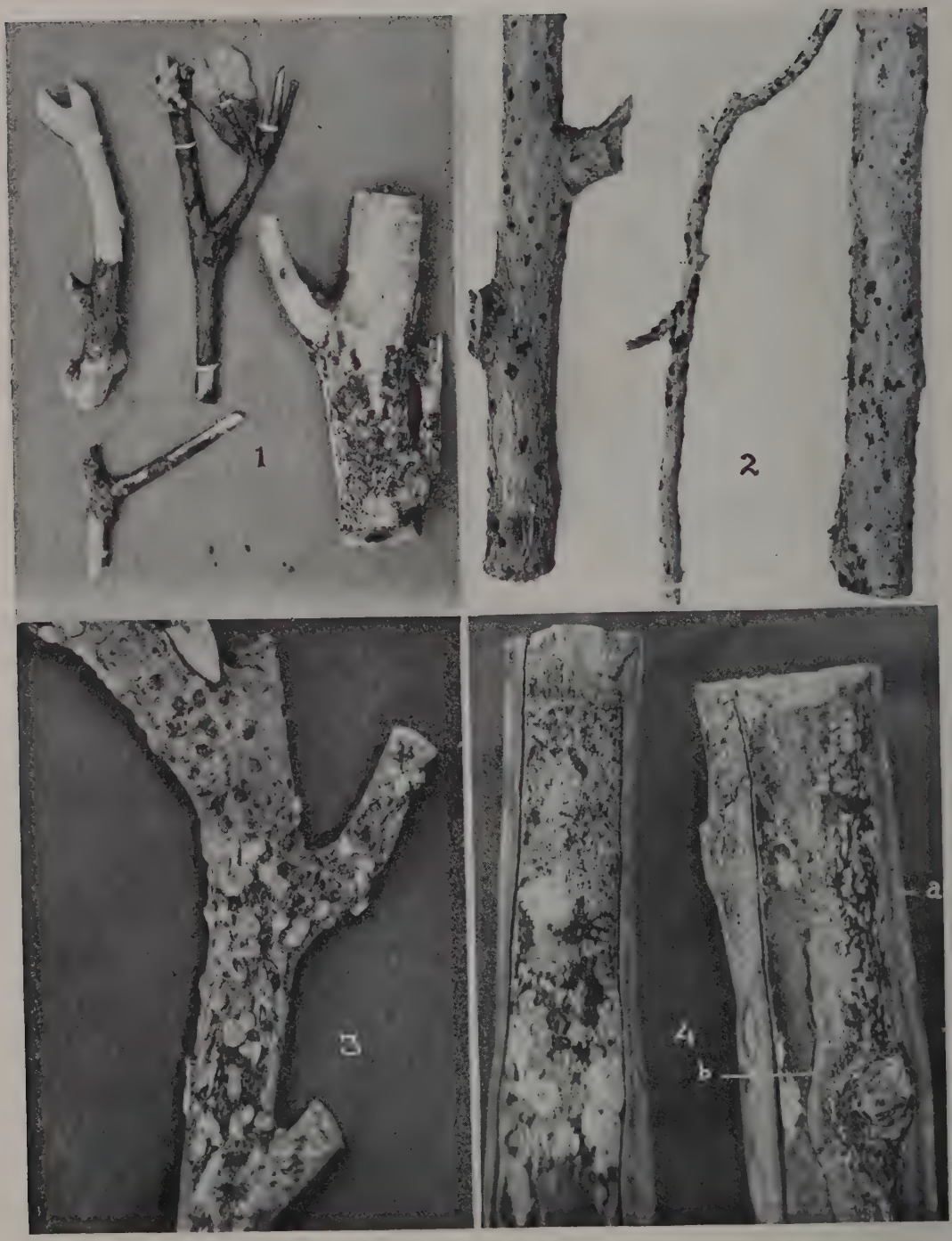
### *Septobasidium bogoriense*, Pat.

### Velvet blight.

The fungus is known as Velvet blight because it forms a bluish coloured velvety coating on the stems. At one time this blight was fairly common on tea in Darjeeling. Now it is only found occasionally. The occurrence of this species in the plains districts is rare. The fungus is wholly external. It does not attack the tea plant except on very rare occasions, even then the damage is negligible. The only harm it does to the tea plant is, it prevents the green portions from carrying out their functions properly, by covering them with a continuous sheet of felt-like mycelium. This felt is up to about 3 m. m. thick, with a bluish-grey surface which in old specimens turns greyish brown. The outer surface is dense and smooth while the internal structure is loose. It commences its life on the tea bush by attacking scale insects. When it has finished the scale insects it sets to work on the tea plant. The fungal felt gradually



**Aschersonia sp.,** on tea shoots. Note the fungal cushions on the green portions of the shoots.




(1), (2) & (3)—Velvet blights; (1) *Septobasidium bogoriense*, Pat, (2) *Septobasidium pilosum*, Boed. and Stelin, (3) *Septobasidium tuberculatum*, Boed. and Stein, (4) *Macrophoma theicola*, Petch. (a) Second ring of callus. (b) First ring of callus.

advances upwards and sometimes spreads to the under surface of the lower leaves, which, are not injured. (see pl. 4, fig. 1). It grows on various other plants besides tea but its presence is always associated with scale insects.

The spores of the fungus are produced free on projections known as basidia.

TREATMENT.—As this fungus is secondary to the attacks of scale insects its infection can be prevented by killing the insects. Branches affected by the fungus should be painted with 1-2% Caustic soda solution. After a few days the fungal growth becomes loose and is easily brushed off. An application of Lime sulphur solution after the removal of the fungus will complete the treatment. The Caustic soda solution should be applied with caution as a higher concentration may burn the bark

### *Septobasidium* spp.

Besides ***Septobasidium bogoriense*** there are several other species which occur on tea (see pl. 4, figs. 2 & 3) and other plants in the North East India tea districts. They are of different colours such as brown, yellowish-brown, purple-brown, reddish-brown, grey or black. The surface texture also varies from velvety felt to woolly fluff. They are not common and their presence has always been found to be associated with scale insects. Some investigators have found a number of these fungi attacking also the host plants but so far not a single species of ***Septobasidium*** has been observed to parasitise the tea plant.

TREATMENT.—Same as ***Septobasidium bogoriense***.

### ROSETTE BLIGHT.

(See Chapter VIII—Rosette blight, page 65).

### CANKER.

(See Chapter VIII—Abnormal callus growth, page 67).

## CHAPTER III.

### *Diseases associated with dead snags.*

*Poria hypobrunnea*, Petch.

This fungus is very commonly found on tea and other woody plants. It has never been found to attack live wood but is very commonly associated with the decay of dead woody tissues. The fungus is not confined to the upper portion of the tea bush alone. It is very frequently found in the roots whence it finds its way through some dead branch. So far the writers have not observed a single tea bush being attacked through the roots alone. Even on the the branches the fungus is not responsible for the death of the wood. The dying back of branches after pruning is not necessarily due to the attack of parasitic organisms. Dry winds, scorching sun and lack of reserves in the plant have been found to exercise a marked influence. Examination of a large number of pruning cuts, one year after they were made, failed to reveal the presence of this fungus. Once the rotting sets in, on such branches, ***Poria hypobrunnea*** is almost invariably present.

The fungus does not develop any external mycelium on the stems but in old cases thin films of yellow mycelium are found on the surface of the wood if the bark is peeled off. On the roots it forms small cushions of yellowish-brown mycelium somewhat similar to those of ***Fomes lamaoensis***, but they are of lighter colour. Also the characteristic incrustation of sand, stones etc., in the latter is not present on a root invaded by this fungus. Yellowish-brown films and cushions develop inside the wood which is soft and rotten. Light brown streaks are also formed on such wood. The fructification of the fungus is a yellowish to fawn coloured incrustation formed mostly on the underside of big branches. (see pl. 5). The colour of the crust becomes dull brown or grey with age.

When examined with a pocket lens the surface of the crust will be seen to be covered with minute round pores. These are the mouths of long, cylindrical cavities in which the spores (basidiospores) are produced.

Fructification of **Poria hypobrunnea.**

TREATMENT.—Careful removal of all dead wood from the bushes, at each pruning, is all that is necessary to control this disease. The larger cuts should be protected from the weather by painting with bitumen paint.

### *Irpex destruens*, Petch.

This is one of the fungi which enter the tea bush through the dead woody tissues on medium or heavy pruning cuts or through dead snags. Like *Poria hypobrunnea*, it is a facultative parasite and its effects on the tea bush are similar. Although this fungus is very common on any dead wood such as decaying logs and shade tree stumps, its occurrence on tea seems to be rare in North East India. Probably its presence on tea bushes is frequently undetected as it takes a longer time to produce its fructifications than the other fungi commonly associated with dead wood. The fungus gradually extends both upwards and downwards from the seat of infection.

The fructifications appear on the lower portion of the branches as thin, vertical plates, adhering to the surface, with thin horizontal brackets at the upper end. Several such plates may be formed one above the other on the affected portion of the stem. The under-surface of the horizontal brackets bears numerous tooth like projections which point downwards. The surface of the vertical plates is marked with numerous vertical furrows. The plates are from ½ inch to about 4 inches across, at first dull-white, then yellowish with a tinge of red. The upper surface of the horizontal brackets bear radial ridges.

TREATMENT.—The diseased wood should be cut down to the clean healthy portion. This may sometimes necessitate collar pruning the bush. The cut should be painted with bitumen mixture. This and several other weak parasites may be prevented by treating the heavy pruning cuts in the above mentioned way immediately after they are made.

### *Auricularia Auricula-judiae* (L.) Schr.

Jew's ear fungus.

This is one of the commonest secondary diseases associated with dead wood. It is neither a true stem disease nor a true root disease. It often invades the larger dead snags on moribund centre stems whence it spreads downwards to the living stem attacking both the wood and the bark and finally extends to the roots. The bark on the above ground portion cracks and wrinkles and the wood becomes soft and rotten. The result is a nasty rotting wound. It does not produce any external mycelium by which its presence can be detected. The only characterstic feature is the formation, during the rains, of soft, brown, gelatinous brackets. The appearance of the brackets resembles that of brown human ears, hence the name Jew's ear fungus. The size of the brackets vary from half an inch to about three inches.

The spores (basidiospores) are produced on the surface of the brackets. Besides tea, it invades old bamboo posts and, in fact, most kinds of dead wood.

Like *Poria hypobrunnea* it may be considered as a facultative parasite.

TREATMENT.—The diseased material should be cut down to clean, healthy wood and the cuts painted with bitumen mixture.

### *Fomes applanatus*, Pers.

This is one of the most common bracket fungi found on dead wood in all the districts of North East India. It is a weak parasite and is very rare on tea. It is sometimes regarded as a root disease but the writers have not observed the fungus to be attacking the roots alone on any of the specimens examined. It has always been traced to some dead wood above ground such as debris left by the floods.

As only a few specimens of this fungus have been found on tea so far, the following description of the fungus has been taken from "The Diseases of The Tea Bush" by Petch.

"There is no external mycelium evident on the diseased roots. The bark is blackened, and sometimes the roots bear small holes, up to three millimeters in diameter, which extend through the bark and appear white at the base. When the bark is removed, small scattered patches of brownish-white mycelium are found between the bark and the wood ; these usually adhere to the bark, and give it a mottled appearance, on the innerside. When the root is split open, the wood has a mottled appearance, being minutely flecked with brown and white. These flecks are very small, and they are not arranged in a honeycomb fashion as in Brown root disease. Any wood which has been exposed in the soil is blackened, with pockets of black or dark brown wood extending inwards.

The fructification of the fungus is produced on the main stem, generally well above ground-level, about the point where it divides into the main branches. It is of the usual bracket shape, and from three to twelve inches in diameter. When extending outwards horizontally from the stem it is generally small, but it may form a mass up to a foot in diameter and several inches thick in the middle of the bush. Its upper surface is zoned, grey and brown, and has a very hard outer crust, but it is dull, and polished. The under surface is white. Internally it is dark brown, fibrous above, and with a thick layer of tubes below".

TREATMENT.—Affected portion should be cut out before the fungus extends below the collar. Removal of the dead wood from the upper portion of the bush at each pruning as well as all debris around it is all that is necessary to prevent the attack of this fungus.

### *Fomes lucidus* (Leys) Fr.

This bracket fungus is parasitic on many trees in all the districts of North East India. Although it is frequently found on jungle trees in the vicinity of tea plants it is not common on

the latter. It is considered as a root disease as the fungus after entering the tea bush through wounds on the stems extends downwards and manifests itself mostly on the roots. The rarity of its attck on tea suggests that it is not capable of attacking vigorous plants.

The wood attacked by this disease becomes darker in colour and contains cavities filled with white mycelium while the outside of the root is covered by tough, thick cords or bands.

The fructification of the fungus is very commonly found on dead jungle trees and is generally bracket shaped. It varies in size from 2 or 3 inches to about 2 feet in diameter and from half an inch to 3 or 4 inches in thickness. On tea brackets are formed on the main stem and the size is usually smaller. The upper surface of the bracket is smooth and white at first, then yellowish red and finally deep red in colour, shining as if varnished. Sometimes the surface is marked with white, yellow and red zones respectively from the margin towards the base. The colour towards the margin gradually deepens until it assumes the same dark red shade as the inner zone. The underside is white and made up of the open ends of myriads of minute tubes in which the spores are produed.

TREATMENT.—See page 19.

*Fomes lignosus* (Klotzsch).

This is a common root disease of rubber in the rubber growing countries. In North East India it is occasionally found on tea and other plants. The disease is included amongst root diseases as it can pass, from the roots of one plant to those of its neighbours, by means of thick mycelial cords (rhizomorphs.) In most cases it has been observed to attack tea bushes through dead wood on the branches. It behaves in a similar manner to other facultative parasites such as ***Poria hypobrunnea***, ***Fomes applanatus*** etc. The disease prefers alkaline soil and is more

prevalent on loose sandy soil. As it is very susceptible to acid conditions and the tea soils of North East India are mostly acid, the disease is rare on tea.

The diseased roots bear on their surface a net work of stout, white or yellowish (sometimes with a reddish tinge), somewhat flat strands of mycelium. The strands run more or less longitudinally and anastomose with one another at intervals. The colour of the strands fades on drying.

The fructifications, which are small horizontal brackets, usually develop on the main stem sometimes singly, frequently several occurring one above the other. These are almost semicircular in shape, usually up to 3 inches across and up to half an inch thick. On big jungle-tree stumps the brackets may attain a much larger size. The upper surface of the brackets is red-brown with a zone of about ¼ inch of yellowish-red or orange colour at the margin. The under surface is usually deep orange. The upper surface, on drying, is marked with concentric, dark brown, rather broad lines and narrow, radial striations. The under surface bears numerous minute holes—the openings of small tubes in which the spores are produced.

TREATMENT.—see page 19.

### *Aglaospora* Sp.

In "The Diseases of the Tea Bush" Petch describes a fungus (*Aglaospora aculeata*) which causes "Thorny stem blight" of tea in Ceylon. The *Aglaospora* observed by the writers on the stems and roots of tea bushes in North East India appears to be a different species from that observed by Petch.

This fungus apparently enters the tea bush through the dead wood on the pruning cuts or dead snags on the main stem. Once it gets into the tissues it seems to spread downwards more rapidly than the other fungi commonly associated with dead wood *viz.*, ***Poria hypobrunnea***, ***Irpex destruens*** etc., and before the diseased

wood at the top reaches the rotting stage the fungus may extend right down to the roots. In several cases the fructifications appeared on the roots while the stem was still hard. However the fungus is not a true parasite.

It does not produce any external mycelium. The wood of the stem is discoloured and at a later stage thin, black, irregular lines and black, rod shaped specks, about 1—1½ m.m. long are formed in it. The wood of the root sometimes turns purplish-black.

The fructifications of the fungus appear on the stem as small round swellings on the bark, about 1-1.5 m m. across, with a thorn in the centre either singly or in groups. On the roots the swellings may be slightly bigger and the thorns longer (projecting about 1.5 m.m. above the surface) than on the stems. The bark cracks at the base of the throns *i. e.*, in the centre of the swellings.

Illustration and measurement of the fructifications have been already published in I.T.A. Memorandum No. 8—Notes on Root Diseases of Tea.

This fungus has also been observed on *Albizzia moluccana* on one or two occasions.

TREATMENT.—By the time the fruit bodies are visible on the stems the fungus is likely to have extended below the collar hence it may be necessary to remove the affected bush, otherwise, cutting out the diseased portion to clean healthy wood will be sufficient to check the disease. The cuts should be protected with bitumen paint.

### *Massaria theicola*, Petch.

This is one of the fungi associated with the dying back of tea branches. This disease is rare in North East India. The few specimens examined were all young bushes less than six years old. So far it has not been observed on older ones. In every case the disease had obviously entered the bushes through pruning cuts. Whether

the fungus is a true parasite attacking bushes through fresh wounds or a facultative one which invades dead tissues at first and then extends to the living ones is not known. Any way the progress of the disease is very slow. It has not been observed to penetrate beyond the collar.

It does not produce any external symptom on the affected portion. If a bush is sawn through the middle longitudinally, the diseased lesion appears discoloured (dark brown) but it remains hard. The affected bark when scraped with a knife looks blackened inside.

The fructifications are embedded in the bark as in case of *Diplodia* disease.

TREATMENT.—The diseased portion of the stem should be cut down to clean healthy wood. The cuts should be painted with bitumen mixture to prevent reinfection.

## CHAPTER IV.

### *Diseases initiated by adverse climatic and cultural conditions.*

#### DIE-BACK.

This is a term applied to the condition of tea bushes in which the branches gradually die from the top downwards. This condition is more often influenced by soil, climate or general health and vigour of the tea bush rather than by any specific disease. Red rust and a number of fungi invade sickly, dying shoots and branches on weak bushes but in most cases they are secondary. These fungi are very common and most of them are associated with dead wood only, others act as weak parasites. These are (*1*) ***Botryodiplodia theobromae***, (*2*) ***Glomerella cingulata***, (*3*) ***Glomerella major***, (*4*) ***Penicilliopsis clavariaeformis***, (*5*) ***Pestalozzia theae***, (*6*) ***Stilbum nanum*** etc., and species of the following genera (*7*) ***Calonectria***, (*8*) ***Cladosporium***, (*9*) ***Fusarium***, (*10*) ***Helminthosporium***, (*11*) ***Leptosphaeria***, (*12*) ***Macrosporium***, (*13*) ***Mycosphaerella***, (*14*) ***Nectria***, (*15*) ***Periconia***, (*16*) ***Phomopsis*** etc.

Some of these fungi and Red rust (*Cephaleuros parasiticus*) have been found so frequently on dying back shoots that their presence on a tea bush may be considered merely as indicative of the weak condition of the bush concerned. The principal conditions likely to induce die-back through debility are as follows.

1. Adverse climatic conditions such as drought and excessive rainfall.
2. Insufficient aeration and acidity of the soil.
3 Injudicious cultural operations such as excessively hard plucking, ill-advised pruning and mal-adjustment of manuring to cropping.

These items are considered more fully in the following pages

TREATMENT.—Care should be taken to remedy as far as practicable the predisposing causes of the dying back. These remedial measures will depend on the requirements in each individual case. For instance the effect of defective aeration can often be removed by improving the drainage and the effect of alkalinity of the soil can only be rectified by altering the pH value. The dying back of a section of young tea after pruning may be alleviated by choosing the proper time for pruning and so on. The condition of growth of the plants concerned at the time of the operation has an important bearing on the subsequent health. Young plants must on no account be pruned during or immediately after a flush. They should be pruned after a banjhi period preferably just before the buds begin to burst.

*1. Effects of adverse climatic conditions on the susceptibility of the tea plant to damage from stem diseases.*

(*a*) DROUGHT.

Young plants with small roots, especially on sandy, porous soil and on stiff soil, where root growth is very shallow, are susceptible to attacks of stem diseases, after a long period of drought. In

exceptional cases young plants wither and die. The dead wood on the top portion of the stem on small plants usually assumes a pinkish colour. The leaves, before drying, are leathery and as they dry, exude a sticky brown substance on the under surface. Those plants which struggle through the droughty period are usually attacked by Red rust (*Cephaleuros parasiticus*) then by fungi such as *Glomerella major*, *Diplodia sp.*, *Phomopsis sp.* etc. It has been observed that older bushes are sometimes very badly affected by drought although they are not killed so readily. The young growth on such bushes withers and drops and the wood on the top of the stems is usually discoloured, light brown. These do not bear any fungal infection for some time but when the weather becomes damper the tissues weakened by drought are invaded by fungi.

(b) Excessive rainfall.

On some areas excess of rain makes tea bushes weak and susceptible to attacks of stem fungi by interfering with the aeration of the soil. This is influenced in more than one way *e.g.*, (1) accumulation of water on the surface of low lying patches, (2) formation of a high water table, (3) flood. The last named one not only interferes with soil aeration but it carries a lot of dead twigs and other debris, usually full of fungi, and deposits them in and around the frames. In some places it deposits a thick layer of fine silt. On a few rare occasions the underside of some of the horizontal branches, lower down the frame of flooded bushes, has been observed to be damaged, apparently by the strong light reflected from the surface of the water.

*2. Effects of insufficient aeration and acidity of the soil on the susceptibility of the tea plant to damage from stem disease.*

(a) Insufficient aeration.

A soil may not be sufficiently aerated without being waterlogged. Some soils, in spite of being well drained and situated well above the water table, may retain water for a long time. Sometimes during

the process of cultivation small pockets are formed round the collars where water collects and again due to the nature of the soil, remains standing for a long time. Bushes subjected to such soil conditions usually suffer from lack of aeration. As a result they turn sickly and become susceptible to attacks of fungi. As a rule the tea plant is fairly resistant to stagnant water on the surface of the soil but plants like the Tung (*Aleuritis* Spp.,) are very susceptible. It has been noticed that fairly old Tung plants are often killed by standing water round the collar. On soils where the water table is very high or where there is a seepage plane, the lower roots of tea bushes may turn black and then decay. Such damaged roots are often invaded by common soil fungi *e.g.*, Violet root rot (*Sphaerostilbe repens*) and the stems may be affected by weak parasites such as *Glomerella major*, *Diplodia*, *Mycosphaerella*, *Phomopsis* etc.

(b) Insufficient acidity of the soil.

The tea plant thrives on acid soils. Although it will grow on under-acid soils it does not flourish. It has been observed that on such soils the roots are usually found full of reserve starch probably on account of the slowness of growth in such conditions. Their stems are in most cases attacked by Red rust and generally appear to be in a moribund state. The roots also fall an easy prey to some of the fungi common in under-acid soils *e.g.*, *Armillaria mellea* and *Fomes lignosus*.

*3. Effects of pruning and plucking on the susceptibility of the tea plant to damage from stem diseases.*

The tea plant in common with other green plants obtains the energy for its growth from sunlight through the agency of the leaves. Carbon dioxide from air and the energy from sunlight are used to form carbohydrates with the water absorbed through the roots. The simple compounds of nitrogen, potash, phosphoric acid etc., absorbed by the plants through the roots are also transformed into more complex substances.

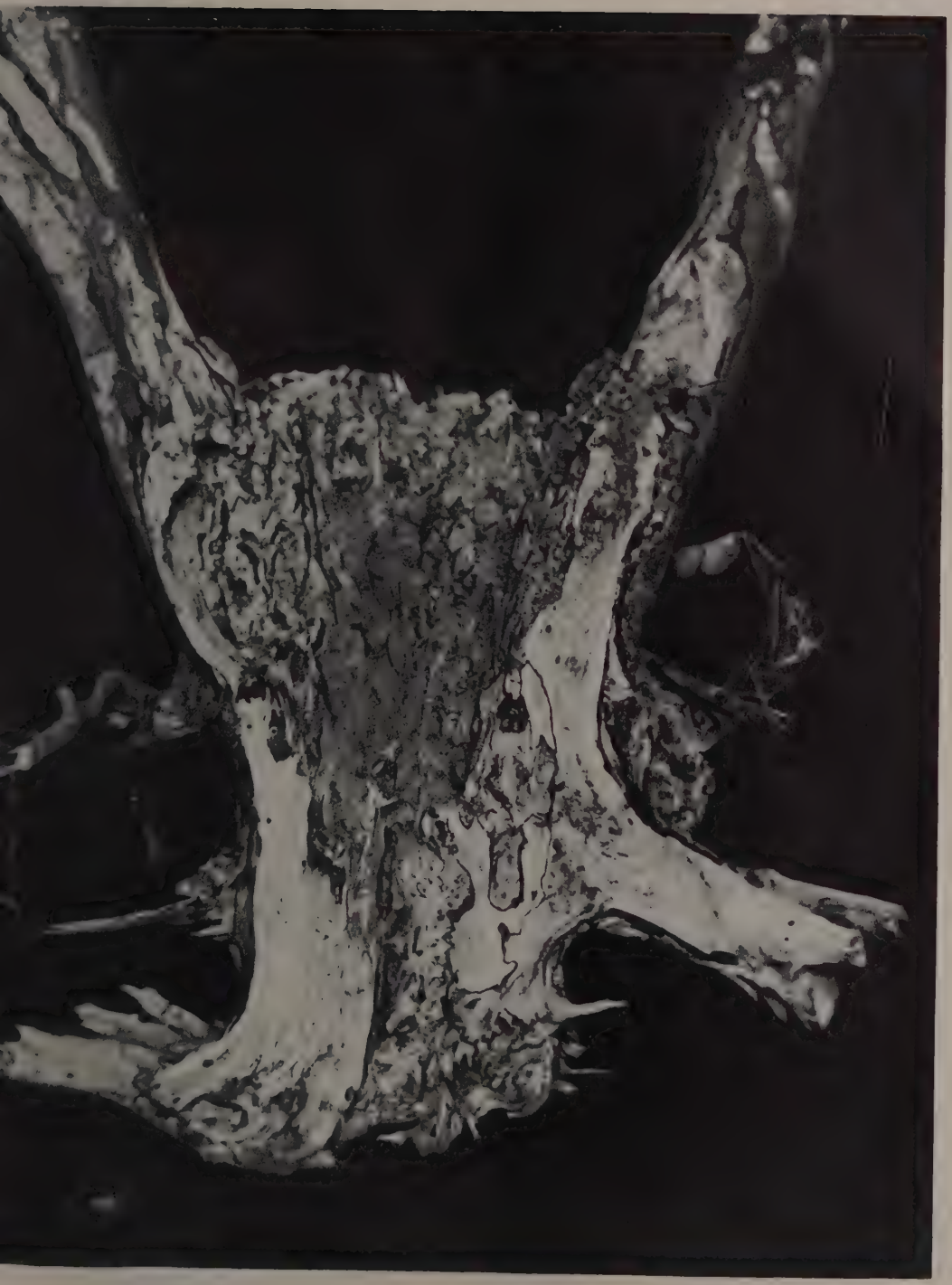
This process of manufacturing plant food is operated in the green portions whence the products are distributed to other parts of the plant. The surplus carbohydrates are stored up in the roots in the form of starch.

No growth can take place without energy. In the absence of leaves no energy can be absorbed and no new growth can be formed, unless sufficient reserve of energy has been stored up. It has been observed that the production of new growth coincided with the reduction in the amount of reserve starch in the roots even on unpruned and unplucked bushes. This reduction in starch is very distinct on pruned and plucked bushes during the period of rapid growth following pruning. When all the leaves have been removed from a plant the new growth takes place entirely at the expense of the reserves. These reserves are replaced as the new growth becomes mature *i. e.*, the amount of starch decreases during periods of rapid growth and increases during periods of slower growth. In the tea plant comparatively little starch is stored up in the stems. Where the starch reserve is low in the roots the new growth coming away after pruning on the younger wood draws upon the older branches to such an extent that the older ones die back. If the reserve in the roots is insufficient to sustain the new growth till it is able to maintain itself, the new growth also dies back. It has been observed that the reserves fluctuate more in case of vigorous young plants than in the case of older ones. This is due to the storage capacity of the roots being smaller relative to the amount of new growth produced on a young plant. Sometimes the new growth on such plants takes up the whole of the reserve in producing a flush. If such a plant is severely pruned immediately after a flush or if the green portions are removed by any other agency, no new growth can take place and the plant dies. Even in case of a healthy and vigorous bush when the green portions are removed by severe pruning, after most of its reserves have been used up in producing a flush, the subsequent new growth is poor and likely to be damaged by parasites usually harmless. *Successful regeneration of a tea bush after severe pruning depends mostly on the amount of reserves stored up in the roots before pruning is carried out.*

Unsuccessful recovery from heavy pruning on areas of old tea frequently occurs in all the plains districts. Bushes do not thrive as expected, branches die-back, at first singly then in groups, and rotting holes form in the centre of the main stems (see pl. 6). These rotting holes gradually extend downwards and after two or three years whole bushes begin to die out. Weak parasites invade the tissues and the external evidence of fungal attack on many of the bushes makes the planter think that the trouble is directly caused by disease. Mycological observation shows that most of the fungi found on such bushes are very common and incapable of doing any damage to vigorous living tissues. It must be assumed therefore that the tissues concerned were already dead or at any rate moribund before they were attacked by these fungi. On larger pruning cuts a few of the surface layers of tissues are always dried up as they are exposed to the weather for a longer time than those on younger cuts. It has been observed that these tissues are not attacked by any fungus for a considerable time. The fungi associated with decaying of frames usually invade these tissues about a year after the cut is made. Even then on healthy vigorous bushes most of the fungi do not extend beyond the dead tissues. It would seem therefore that the trouble is more directly associated with pruning than with fungal infection.

Individual bushes sometimes die without being severely pruned and without being attacked by root disease. In such cases the source of the trouble may generally be traced to an old dead snag somewhere in the centre of the frame. It has been noticed that a decaying snag rarely forms on a healthy vigorous bush, even if it does it generally drops off and the place, where it had been, is healed over. It is usually the weak bushes that are damaged by those fungi which spread from dead snags. There are exceptions to this. Some individual plants are specially susceptible to branch decay. In some strains of Lushai this is particularly noticeable. Bushes growing on plots heavily manured with nitrogen also seem to be more susceptible than those on which the growth is less succulent.

Hard plucking has often been observed to increase the susceptibility of tea bushes to die-back and associated attacks of fungi. The



Section of a tea bush showing rotting hole in the centre.

leaf area remaining on bushes after hard plucking is often insufficient to take up the surplus energy required to build up reserves. Eventually the bush becomes weaker.

*Macrophoma theicola* (Petch).

This stem disease has so far been observed to occur on tea mostly in the plains districts. It has also been found on Boga medeloa (*Tephrosia candida*) and other woody plants.

The disease first appears as slightly sunken patches on hard portions of tea branches. These patches are very variable in size and shape. During the first year they are usually small. Later, it is not unusual to find patches up to several inches in length and more than an inch in breadth. In almost every case the diseased patch is surrounded by a ring of callus growth a reaction on the part of the plant to repair the damage. Although the fungus does not spread rapidly, this attempt, to seal up completely the diseased area, rarely succeeds as the callus growth is usually unable to keep pace with the disease. It is often attacked and killed by the fungus before advancing very far and a new ring is formed a little further away and thus a second or even a third ring of callus is sometimes formed in succession (see Pl. 4, Fig. 4). On older branches the growth of callus is much slower than on younger ones and the margin of the diseased patch is marked only by a slightly raised ridge. The bark and the wood to some depth, inside the callused ring is killed; the tissues become discoloured, and are latter rotted by other fungi. Occasionally the disease extends down the main stem, into the root uniformly discolouring the wood. As a rule the branch above the diseased patch is killed if the diseased tissue is not cut out. The whole bush may be killed should the fungus extend right through the main stem.

In the hotter parts of North East India—especially where there is liability to droughts in the cold weather a branch canker similar to that caused by this disease develops some time after heavy pruning. This is associated with pruning and sun-scorch and not with any fungus disease.

Cuts made by hail are often confused with this disease but it should be noted that the bark in the former is usually removed while in the latter it persists for a considerable time. Of course it is not unusual for the fungus to attack plants through such lesions as well as those affected by sun.

If the diseased bark is shaved lightly with a sharp knife especially close to the ring of callus, minute cavities (pycnidia) either isolated or in groups may be revealed. During the rainy season these are usually filled with a white substance—the spores in mass. At other times they are more often found empty. The higher stage of the fungus (the perithecial stage) is less commonly found. This appears to be the same as the pycnidia but it differs microscopically.

This disease is usually secondary, sunscorch or drought being the primary cause.

TREATMENT.—The diseased material should be removed to clean healthy wood and the cuts washed with a fungicide and waterproofed with bitumen paint. The diseased prunings should not be left lying about. They should be buried or burned immediately.

### *Glomerella major* Sp. Nov.

During an investigation of the diseases of woody branches, a fungus was very frequently isolated from apparently sound wood in the vicinity of rotting lesions on old wood, also on sickly branches from one to three years old. This fungus was at first confused with Brown blight (*Glomerella cingulata*) on the leaves, but further investigations showed that it was distinct.

The fungus is usually associated with a moribund condition of the branches concerned, although its presence on the bark of apparently healthy twigs is not unusual. It is almost impossible to detect its presence on a branch as it does not produce any external mycelium or other characteristic symptom. The only indicative feature is that the smaller, one to two year old branches, when affected by this fungus, fail to come away at the top portion after pruning.

On fairly healthy bushes, new healthy shoots may develop below the affected portion *i. e.* a few inches away from the pruning cut. This bare portion of the stem may not be dead but in most cases it is affected by *Glomerella major*.

On the twigs, the fungus is at first mostly confined to the phloem (the bark tissues). It gradually extends as the branch concerned becomes less vigorous and eventually penetrates the woody tissues. This suggests that the fungus is a facultative parasite.

It produces two kinds of spores (see Pl. 12, figs. 10—17). The conidiospores are produced in the rainy season and a perithecial form at the beginning and end of that season. In the field this latter form remains immersed in the bark while in a damp chamber it is not uncommon to find it growing freely on the surface.

TREATMENT.—Direct treatment on this disease is neither possible nor necessary. Attention should be paid to improving the general condition of the bushes as this disease is only likely to be harmful to bushes which lack vigour.

*Botryodiplodia theobromae.* Pat.

= *Thyridaria tarda*, Banc.

*Diplodia* disease.

Like ***Sphaerostible repens*** this fungus is also a weak parasite but it is not a true root disease. It is capable of attacking stems and roots equally alike. Occasionally it is found even on the leaves. It is one of the commonest fungi found on dead wood. Sickly branches and twigs, dead tissues on pruning cuts and roots of the tea bushes which have been weakened by some other cause are all liable to be invaded by *Diplodia*. It does not attack healthy vigorous bushes.

Detailed description of this disease has been published in I.T.A. Memorandum No. 8—"Notes on Roots Diaeases of Tea". It does not develop any distinguishable characteristic on the stems. The wood of the affected bush is often bluish but such discolouration may also

be produced by other agencies. The fructifications—spherical bodies containing spores—are almost always embedded in the bark so that they escape even the notice of trained eyes.

TREATMENT.—Treatment on Violet root rot, given below, is also applicable to this disease.

*Sphaerostilbe repens*, B & Br.

Violet root rot.

This root disease is very common in all the tea districts of North East India but it is a weak parasite. It has been described and illustrated in I. T. A. Memorandum No. 8—"Notes on Root Diseases of Tea".

One of the two types of fructifications is produced on the main stem at the collar or a little above it, occasionally at the base of the branches. This consists of clusters of black, minute flower-bud like structures. These clusters are at first red but soon change to black.

TREATMENT.—Treatment and prevention of Secondary Root Diseases, I. T. A. Memorandum No. 8, applies in this case; it is repeated below.

In the case of root disease associated with fungi which are normally present in the tea soils it is obvious that the fungus concerned is not the prime cause of the ill health of the diseased bushes. There must be factors which have rendered the bushes especially susceptible to the attacks of such fungi. Any combination of factors which tends to render the plant less vigorous is liable to increase susceptibility to disease of this kind. It does not follow that the same factor or combination of factors is operative in all bushes affected by a specific secondary root disease.

*Reserves of energy.*—One of the principal factors governing the vigour of a tea bush is the energy supply. Most, if not all, of the energy required by a green plant is obtained by the absorption

of light by the green portions. The effective energy-absorbing area is conditioned by the plucking and pruning which the plant undergoes. The leaf area may be further reduced by the ravages of pests and blights.

The following simple test, carried out in the cold weather, will indicate whether the bushes growing on a particular area are deficient in energy reserves. A healthy lateral root, about half an inch in diameter, should be taken from each of about a dozen bushes taken at random. The end of each root should be cut smooth with a sharp knife and treated with a weak solution of iodine. If the cut surface goes a deep purplish-black all over, it means that the root is well filled with starch. Starch is one of the most important reserves containing energy. If the cut surface does not go black all over at the time of the year in question lack of energy reserve is suggested. During the growing season the amount of starch fluctuates considerably. It is less at the end of a flushing period and more at the end of a banjhi period. During the dormant season the starch remains more or less constant and the relative amount present in the roots at that time may be taken to be representative of the energy reserves of the bush concerned.

*Manuring*.—The work of the chemical section has shown that the most important chemical substance which the tea plant requires is nitrogen in a form available for its use. Nitrogen stimulates the growth of new leaf and thus increases the energy absorbing area. If however all the extra leaf induced by the manuring be removed the balance of energy absorbed may be affected adversely. Energy is required for the production of new growth and the latter does not absorb any surplus of energy until it has reached full growth *i. e.*, until some time after it has reached the stage suitable for plucking. At the same time manuring with nitrogen, if sufficiently heavy, also tends to increase the leaf area below the plucking level. Thus the application of nitrogenous manures is likely to assist tea bushes to maintain their vigour and in consequence to resist the attacks of secondary root diseases. The effect on the vigour of the tea plant

produced by suitable manuring may be enhanced by temporarily reducing the amount of leaf removed. This may be done by raising the plucking level or in some circumstances by allowing the bushes to remain unplucked for a portion of the growing season. No general rules can be made in regard to the resting of tea plants. Each case requires to be considered on its merits.

*The physical condition of the soil.*—Root disease of the secondary type is usually more prevalent on bushes growing under unsatisfactory soil conditions. This is not because the soil conditions are more suitable for the growth of the fungus concerned but on account of their effect on the growth of the tea plant. When a tea plant is growing under unsatisfactory conditions there is a greater tendency for the effective leaf area to be limited and the effects of undue reduction of leaf area by overplucking, Red spider etc., are more rapidly apparent. The most common soil defect indirectly associated with secondary root disease is lack of aeration. It is more frequently due to the nature of the soil than to the lack of drains. This is often illustrated by lines of poor bushes bordering drains, on which poor subsoil has been spread. Much can be done to improve the physical condition of such soils by judicious manuring.

### *Corticium dealbans*, Sp. Nov.

### White *corticium*.

This disease is found in all tea districts. During 1923 and 1924 it appeared mostly on the gardens bordering the Himalayas. It has not been observed to do any appreciable harm except where the tea is exposed to hot dry winds. It apparently causes little immediate damage on vigorous tea bushes unless the conditions become unfavourable to the tea plant. Some years ago all the tea bushes on the plots adjoining the Tocklai laboratories were found to be infected by this fungus. It is probable that the outbreak originated from infected specimens received at the laboratory. In spite of this general infection the tea remained vigorous. Some bushes purpo-

(1) White Stem blight, (2) *Corticium dealbans,* (3) Fructifications of same (4) Thread blight, (5) *Aleurodiscus* sp.,

sely left untreated for a year after infection were marked to be distinctly behind their neighbours. A few of the weaker stems died back but they were far from becoming moribund. In recent years no treatment has been given and although the disease is still wide spread no particular harm has accrued. Itshould be noted that the tea in question is very vigorous. Weaker bushes may have responded differently.

The fungus attacks the bark of the young wood bleaching it. The dead strips of primary cortex on the outside of this bark are usually unattacked, and in consequence retain their normal colour emphasizing the whiteness of the bleached areas beneath (see pl. 7, fig. 2). The fungus usually starts at forks on the young woody stems and spreads thence until the whole of the brown bark is bleached, it then sometimes extends to the bark of the older stems but so far has not been found on the green shoots.

The fructifications are pinkish patches about ½-1½ inches long and ⅛—¾ inch across (see pl. 7, fig. 3). These are produced usually below forks on the younger brown twigs. Sometimes they are also found on small dead twigs. These patches bear numerous basidia on which two or four spores are produced.

(This fungus was referred to as *Corticium* sp., 1 in the I. T. A. Quarterly Journals).

Treatment.—This disease is easily controlled by spraying the bushes after pruning with Lime sulphur solution. Attention should be paid to the improvement of the general conditions of the bushes.

### *Cephaleuros parasiticus* (Karst).

Red rust (parasitic).

This is one of the commonest diseases of the tea bush in all districts of India, especially in the plains. With the exception of the higher parts of the hill gardens it may be said to be present everywhere. According to Mann and Hutchinson this disease was definitely recognised as a tea blight somewhere about 1890 when

it was detected on twigs sent from Nowgong (Assam) to the Botanical gardens, Calcutta, although it is said to have attracted attention long before that time. It was then known as "White blight"—a name which was given from the variegated appearance sometimes assumed by the leaves on the branches attacked by this disease. When first discovered it was thought to be confined to the leaves alone and its presence was not considered to be important. Only since the beginning of this century the importance of this disease, as one of the most serious blights of tea, has been realised.

Unlike other diseases of tea, Red rust is caused by an alga. How the name Red rust was adopted is not known but from mycological point of view it is certainly an inappropriate term. The term rust is only applied to the diseases caused by a particular class of fungi but the organism producing Red rust is not a fungus. It belongs to the same class as the sea weeds, the green and red scum on the surface of stagnant pools and the green, slimy, hair-like plants found in streams, ponds, damp surfaces etc. Very few of these are parasitic like Red rust. Even the name Red rust itself includes three different forms two of which are harmless. One of these two forms is known to be caused by another species of ***Cephaleuros***—***Cephaleuros mycoidea*** (Karst). These will be dealt with later on.

The name Red rust is probably given to the alga from the orange red appearance which the patches on the leaves and twigs assume when the fructifications develop.

The alga is very common on the leaves of tea. It penetrates the tissues of the leaf and causes at first small, watery, translucent spots, often circular, on the upper surface. These gradually turn purple and extend right through the leaf appearing on the under surface assuming a similar but dirty appearance. On the upper surface generlly the spots are slightly raised above the leaf surface. This gives them a swollen appearance. The surrounding leaf tissues become darker thus forming a dark or purplish-red margin. Sometimes a watery green ring of tissues surrounds the purple spots.

When old the fructifications of the alga develop at the centre of the spots either on the upper surface or on both the surfaces. Ultimately the spots become dry and the central portion sometimes becomes grey and falls off leaving a small hole. The diseased spots on the leaves are usually up to ¼ inch in diameter but several spots may coalesce and form a bigger one.

On the stem the spores of the alga enter through the cracks in the newly formed bark on young hardening shoots. The spores give rise to fresh algal cells which penetrate into the bark and kill the cells in a patch. Here the disease is only discernible in its characteristic form when the red fructifications develop during the early rains. At other times of the year, when the red fructifications are absent, the diseased patches on a fairly thick stem are difficult to find. They are purplish or slightly dark, somewhat swollen areas occasionally with small longitudinal cracks on the surface. The alga grows slowly or remains dormant until the conditions become favourable for its growth. The patches on the stem may vary from a few millimetres to about 1¼ inch in length and up to about ¾ inch in breadth. It is not unusual to find the whole length of a stem to be covered on all sides with the orange red fructifications. Occasionally small, scaly, grey patches are formed when the green shoots are attacked.

The fruiting patches are composed of tiny orange coloured filaments with knobs at their ends. These small red pins arise side by side in a mass and when held against light present a forest-like appearance. The spores are produced in the knobs of these pins. These pin-like structures are barely large enough to be seen with the naked eye and should not be confused with the much larger fruits of a saprophytic fungus called *Stilbum nanum*.

Sometimes the alga (probably the harmless one) goes into partnership with a fungus and forms small circular grey spots, which, entirely cover the upper surface of leaves growing in damp shady places. This form is purely 'superficial' and harmless (see Lichens, page 63).

The leaves of bushes on which the branches are severely attacked by Red rust, lower down, sometimes present a variegated appearance. In some cases the whole leaf may become white. The affected bushes usually bear thin, weak, wiry twigs with a few poorly grown leaves at the top and none lower down. The bottom leaves fall off exposing the undeveloped buds at their axils.

In spite of the alga being universally present, the healthy, vigorous tea bushes do not suffer from it, but if for any reason the vitality of the plant is impaired it becomes a serious parasite. The condition most likely to cause Red rust is lack of aeration of the soil. Hard pan, waterlogging and a bad physical condition all do this. One of the effects of hard-pan and waterlogging is the production of shallow roots and if a drought occurs it is of course the shallow rooted plants that suffer first. Deficiency in some important soil constituent may also be a contributing cause of this disease in a few cases. A high pH value has been observed to be associated with severe Red rust, in some areas. Any system of pruning which leads to the formation of weak twiggy wood is dangerous in point of view of Red rust. Plucking too closely leads to thin weak wood, especially if carried out early in the season.

Besides tea, Red rust is found on Boga medeloa (*Tephrosia candida*) Sau trees and many other plants.

TREATMENT.—The treatment of Red rust already published in I. T. A. Memorandum No. 14 "Red rust", is repeated below.

Spraying with Bordeaux mixture (similar to Burgundy mixture but made with quick-lime instead of soda) was introduced to tea in North East India with the object of palliating this disease. It was found that applications of 1 percent Bordeaux mixture made in the cold weather prevented a great deal of the disease.

For very many years it was the custom to dip young plants into Bordeaux mixture at the time of planting out. This was almost invariably done in the case of infills for the specific purpose

of preventing Red rust attacks. With improved cultural methods the dangers of attack were much reduced and the custom was gradually abandoned. Now-a-days when planting out is almost all being done on old tea soils and the growth of the young plants is not likely to be so vigorous, it would be worth while to reintroduce it, using either 1 per cent Burgundy mixture with rosin adhesive or ½ per cent Perenox. The thorough spraying of young tea with either of the above solutions early in the cold weather each year would also be worth while.

The efficacy of treatment with copper fungicides as a palliative of Red rust is not in question. It was well established by Mann and Hutchinson in 1904-7. They also found out that spraying at the time the fructifications are visible i. e., early in the growing season is not so effective. It does however save some of the less severely infected twigs. This may be very important in the case of young plants.

Spraying with Burgundy mixture or other suitable copper mixtures kills the alga even when it is within the tissues as the damaged tissues readily absorb copper compounds. It is obvious that the best time to spray tea plants to prevent damage from Red rust is in the cold weather just after pruning. At that time less fluid will be required to wet all surfaces and there is less danger of its being washed off by rain before it has had time to penetrate the infected tissues. The application of suitable spray fluids at that time will do much to prevent damage from Red rust during the somewhat uncertain conditions early in the following season.

The application should be thoroughly done so that the bark of the younger wood is well wetted. In the case of plants under 5 years old, the whole plant should be wetted. It is therefore necessary to use an adhesive in the fluid. 1 per cent Burgundy mixture with rosin adhesive is found satisfactory for this purpose. ½ per cent Perenox is also a good substitute. As the Perenox contains a wetting compound it is unnecessary to add an adhesive to it.

Little damage will result from any infection which may occur in June, July and August until the following March, April and May. Instances have been noted of severe damage occurring in October and November but these are exceptional and may be associated with exceptional climatic conditions. Spraying early in the growing season may have prevented such damage but it was impossible to estimate the need for this application until the damage had occurred. Although the most satisfactory time for spraying is just after pruning, application made at any time before the beginning of March will be likely to prove satisfactory. Later than this the chances are that it will be too late to prevent serious damage although some of the less seriously attacked stems may be saved.

### *Cephaleuros mycoidea* (Karst).

### Red rust (epiphytic).

Formerly the parasitic form of Red rust was named as ***Cephaleuros mycoidea*** but Petch suggests in his "Diseases of the Tea Bush" that there are undoubtedly two species which occur commonly on tea *viz.*, ***Cephaleuros mycoidea*** (the epiphytic Red rust) and ***Cephaleuros parasiticus*** (the parasitic Red rust). Both the species being orange red, are similar in appearance. The epiphytic Red rust has been observed only on tea leaves growing in shady places. It has not been found to grow on stems, not even the green ones.

### Sun-scorch.

A branch canker very similar in appearance to that caused by ***Macrophoma theicola*** is frequently observed in the plains districts of North East India. The affected areas, in the early stage of development of the disease, failed to reveal the presence of any fungal infection. It was found that the death of the tissues occurred before any infection had taken place. From a number of observations, made by the writers, it was obvious that most of the branch canker in North East India is associated with sun-scorch and is the result of the climatic conditions immediately following the time of pruning. Observations on the damaged tissues on such cankered branches showed that at Tocklai they remained uninfected by pathogenic fungi for at least a year.

Cankers caused by sun-scorch are often mistaken for those caused by *Macrophoma theicola*. There is however some macroscopic differences between the two. (1) *Macrophoma* cankers may occur all over the tea bush without any tendency of the fungus to confine its attack to a particular aspect. Whereas sun-scorch cankers are consistently present on the southern and south-western aspects of the bush. (2) Both stouter branches and the thinner ones are equally susceptible to attacks of *Macrophoma* while the thinner branches on the top of the bush are not damaged directly by sun-scorch, only the thicker ones, lower down the bush, are injured. (3) The bark on the damaged area persists for a comparatively longer time in case of *Macrophoma* than in sun-scorch. In the latter it cracks, curls up and peels off. (4) The position of the branches makes no difference to the attack of *Macrophoma*, while, sun damage is less evident on the vertical branches than on slenting and horizontal ones. (5) *Macrophoma* patches are usually isolated while those of sun-scorch may extend throughout the whole length of the branch. (see pl. 8).

The wood tissues immediately below the damaged bark, in case of sun-scorch, are invaded, some time after the damage has been done, by a number of fungi both parasitic and saprophytic. *Macrophoma theicola* is not infrequently among these. The death of the woody tissues gradually extends inwards especially where the bark has peeled off. Sometimes the damaged tissues are removed by white ants and there being no fungus parasite going ahead into the healthy tissues, the branches concerned continue to grow well and remain productive. In such cases the damaged area is marked by a distinct canal. The surface of the wood so exposed is usually hard and smooth.

Treatment.—As the damage is more evident on heavily shaded bushes which are pruned before September it would be advisable to defer pruning until the beginning of cold weather. Where earlier pruning is unavoidable the bark should be white washed immediately after pruning. On badly damaged bushes white ant infection

should be induced, by placing thatch and grass around the bushes, for cleaning out the dead material. Although some of the living wood is likely to be damaged in some cases by the white ants, this operation is worth trying as it will protect many of the affected bushes from the attacks of weak parasites. It is however dangerous to attract white ants to young tea plants.

### Lightning.

During the rainy season it is not unusual to find tea bushes dying out suddenly in patches of 15, 20 or even larger numbers. Sometimes an unaffected shade tree is included in such a patch. The leaves of the tea bushes wither, turn brown and the bushes die for no apparent reason. The cause of death is often attributed, to some root disease, harboured in the roots of the shade tree, if there is one present or to some kind of stem disease. In many cases however the bushes have not been killed by any fungus disease, but by lightning. It is generally possible for the planter to distinguish between the effects of lightning and those of root disease.

(1) In case of a root disease of primary nature a few bushes (usually not more than 5 or 6) may die at one time on one side of a shade tree and further deaths of 2 or 3 bushes may occur from time to time but they do not die in great numbers very suddenly.

(2) Roots of bushes killed by root disease show some symptoms of the fungus concerned either on their surface or in the tissues whereas the roots of those affected by lightning have a normal, healthy appearance.

(3) In case of lightning if the bark and the wood of the bush from a few inches below the soil surface up to 1 or $1\frac{1}{2}$ feet above it be chopped with a 'dao' (a big knife) the wood will usually be found to have become dark brown. This discolouration is not usually present on the top portion or on the roots. Some root diseases cause discolouration of the root tissues and sometimes the lower portions of the stems but the colour is not the dark brown characteristic of severe lightning damage. The discolouration of the tissues is due to the plasmolysis of the cell contents caused by the lightning.

Bushes slightly affected by lightning such as those in the outside ring of a severely affected patch may die some time afterwards. The dark brown discolouration may not be noticeable on such bushes.

In some gardens lightning damage occurs in some particular areas year after year. Observations made in such cases have shown that during the rains either the water table in such areas is higher than that in the neighbouring areas or there is a seepage plane, in the latter case the damage is usually done along the line of the plane.

Treatment.—Bushes severely affected by lightning should be dug up at the earliest opportunity. Those situated in the outside ring of the patch and less severely damaged should also be uprooted and replanted along with the rest.

## Hail Injury.

The frame of the tea bushes is sometimes very badly injured and young plantations are occasionally killed right out by severe hail storms. Unfortunately hail storms often occur just after the new growth has been formed when much of the reserve of carbohydrates has been used up. If a new clearance happens to be exposed to hail immediately after a flush and damage has been sufficiently severe to remove all the leaves, most of the plants will die and nothing can save them. They have no energy reserves for producing further growth and no leaves for the absorption of new supplies of energy. Larger bushes often survive such a disaster, as their storage capacity is relatively greater, although there may be a temporary set-back. Hail bruises the branches—especially the horizontal ones—on their upper surface at intervals and the bruised bark may be stripped off. On vigorously growing bushes hail wounds usually heal over before fungi infect them but sometimes wound parasites such as *Nectria cinnabarina* and other fungi *e. g.*, *Macrophoma theicola*, *Diplodia* etc., infect the bushes through such cuts and the branches concerned die some time later.

Damage caused by hail is occasionally confused with an attack of *Macrophoma* but where the latter occurs independently of hail the lesions retain the dead bark for a long time whereas the bark on the hail damaged patches is more often missing. Hail-cuts are rarely

found on the underside of the branches while *Macrophoma* may be found on all sides.

TREATMENT.—Tea severely damaged by hail should be sprayed immediately with a fungicide to prevent infection of the wounds by fungi such as *Nectria cinnabaria*, *Macrophoma*, *theicola* etc.

Young tea when partially defoliated by hail should be sprayed with a fungicide to protect the remaining leaf area from attacks of leaf disease such as Brown, Grey and Copper blights. Sometimes it may be necessary to apply an extra dose of quick acting manure on such tea to stimulate the leaf growth and leave more leaf in plucking.

## CHAPTER V.

### *Diseases affecting the stems of seedlings.*

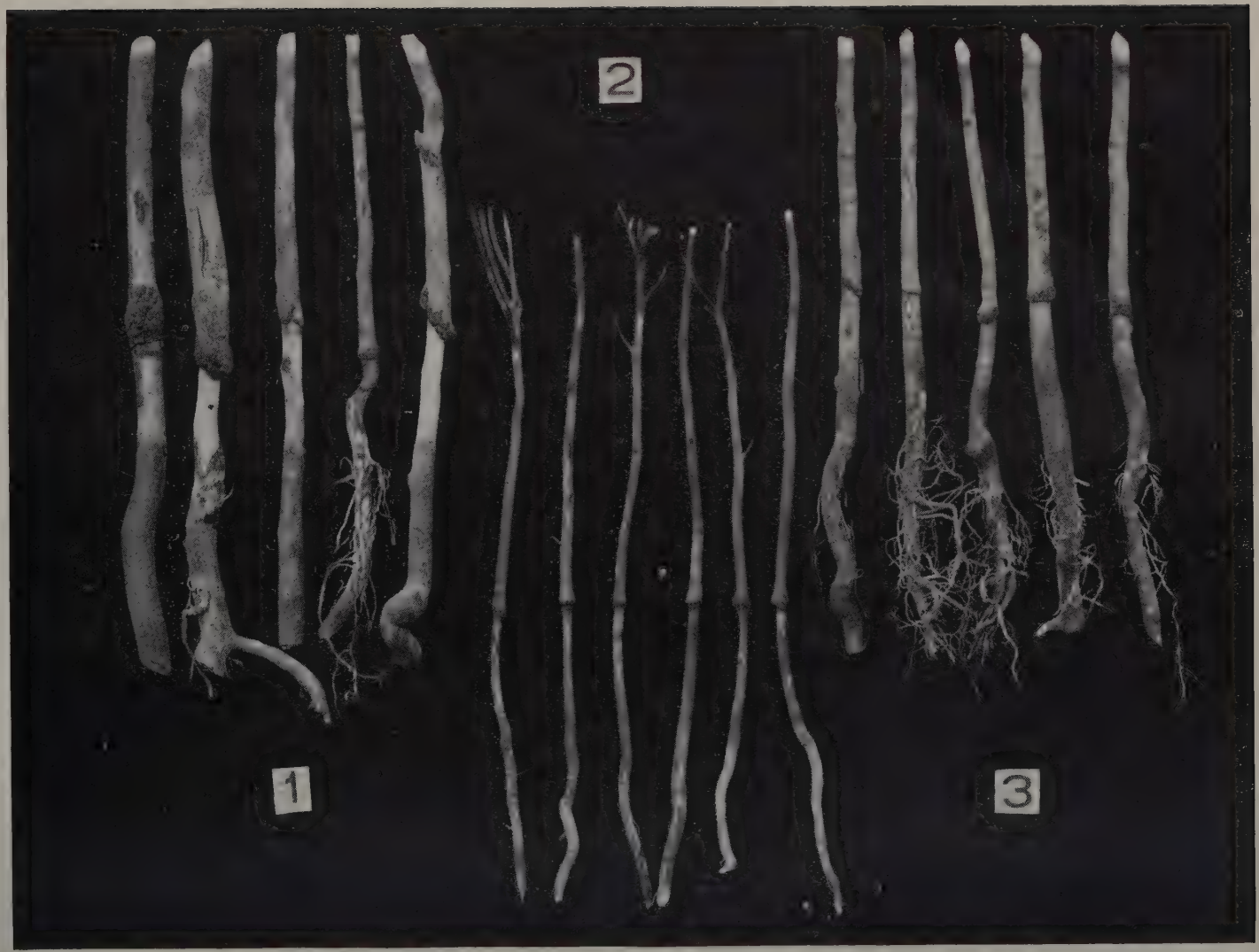
*Phomopsis* Sp.

Collar rot of seedlings.

This fungus is the cause of a very common disease of young tea seedlings in the nursery, throughout the tea growing area, of North East India, especially where the soil is of a sticky nature or where it tends to form a crust on the surface when exposed to heavy rain.

It attacks the main stem of the young seedlings, (up to about 6 months old) in a ring, near the soil level. This ring extends over a region of 1 to 2 inches above and sometimes about ½" below the ground level. Occasionally it starts a little above the surface, about ½". There are no obvious signs by which the disease may be diagnosed in the early stages.

On badly attacked seedlings the diseased portion is usually of smaller diameter than the adjoining unaffected portions above and below it. If the diseased portion is scraped with a pen-knife the wood is found to be discoloured, at first brown then slightly bluish. Black lines or rings are often present in this portion in severely affected cases. As the progress of the disease is almost equal all round the stem the edge of the discoloured patch is regular in most cases. Another characteristic behaviour of this fungus is that whenever a seedling is attacked it is always completely ringed. The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patch may vary in length but the attack of the disease has never been found to be confined to one side only of the plant. This fungus does not usually attack seedlings later than 6 or 7 months after sowing. The effects are noticeable some time after the fungus has done the damage—usually towards the end of the rainy season as soon as a period of hot dry weather comes on. Scattered individuals, occasionally in groups, all over the beds, wither and die for no apparent reason. The slightly affected ones turn sickly but do not die right out. These subsequently develop at the upper edge of the diseased patch, a ring of callus, which pushes the bark up (see pl. 9, fig. 2). Such seedlings may survive for a few months or a few seasons until they are subjected to some adverse conditions of growth. The disease starts its work, after the heavy rains, underneath the surface crust, through the bark gradually extending into the wood and ultimately into the pith.

The water continues to be absorbed by the roots and to flow upwards through the undamaged woody tissues so long as there is sufficient energy reserve in the roots in the form of available carbohydrates to maintain the health and vigour of the roots concerned. The replenishment of this reserve is impossible until the callus has bridged the gap caused by the fungus. If the gap is not bridged in time the root dies and absorption ceases. The dry atmosphere at the beginning of the cold weather makes more apparent the withering due to the lack of water from the roots.

An effect similar to that caused by this fungus is sometimes produced on plants by heat. This will be described later.

The fructifications of the fungus appear as minute black scattered dots on the bark of the diseased portion.

TREATMENT.—There is no ready method of detecting the presence of this disease in the nurseries at the beginning of the rains. The following preventive measures should be adopted.

(1). The nursery beds should be shaded with a flat thatch shade about 5 feet high. This will also be effective in reducing eelworm infection.

(2). The nursery beds should be sprayed with 1% Burgundy mixture or 0.25% Perenox once before the heavy rains are expected and again after about 6 weeks in a lull in the rains. After this the seedlings should be sprayed leaves and all with Lime sulphur solution (8° Beaume 1 part and water 8 parts) once a month till September.

Burgundy mixture or Perenox should on no account be substituted for Lime sulphur solution in the subsequent sprayings as copper mixtures sometimes affect the growth of the seedlings if used too frequently.

(3). The surface crust, wherever found, on the nursery beds should be broken before carrying out the spraying operations, care being taken to prevent damage of the collar with sharp instruments.

The above treatment will do a lot to prevent damage also from other fungi, such as *Pythium* sp., *Rhizoctonia* sp., *Gibberella* sp., etc., which attack the collars as well as from leaf fungi such as Brown and Grey blights thus tending to ensure a higher percentage of good plants.

### *Pythium* sp.

This fungus sometimes attacks young tea seedlings, in their first six months, growing on a sticky soil or where the soil tends to form a crust on the surface after heavy rains. It is a fungus belonging to the same genus as that which causes the "damping off" of cabbage and other young seedlings. The fungus attacks the main stem and a portion of the root in a ring near the soil surface. This ring may extend up to an inch above and about ½—1½ inches below the soil level. Infection takes place immediately below the surface crust, whence the fungus extends through the bark and if the weather continues to be wet and dull it grows through the woody tissues into the pith.

The only outward sign, characteristic of this disease is that the bark becomes very soft and if scraped with a knife both the

bark and the woody portion of the affected area appear to be sodden. Slightly affected seedlings may survive for some time as in the case of *Phomopsis* sp., until adverse climatic conditions finish them off. Sometimes on such seedlings, where the fungus has not entered the wood it disappears altogether from the tissues leaving no clue as to the cause of their death.

TREATMENT.—The treatment suggested for *Phomopsis* sp., is also applicable to this fungus (see page 55).

### *Rhizoctonia* sp.

A species of *Rhizoctonia* has sometimes been observed alone in the tissues of young seedlings damaged in a similar manner to those attacked by *Phomopsis* sp., or subjected to excessive heat. Whether the fungus is responsible for the death of the seedlings or it is only a saprophytic soil dweller that invades the tissues after the plant being killed by some other agency is as yet unknown.

This species of *Rhizoctonia* is not common on tea.

### *Gibberella* sp.

Like *Rhizoctonia* sp., this fungus has also been found on rare occasions at the collar of seedlings (less than six months old) suspected of being attacked by *Phomopsis* sp. The fungus was also found at the soil level on green shoot cuttings of tea which died after producing roots. It is not known whether the fungus is secondary but the effects produced on young seedlings were identical with those of *Phomopsis* sp.

## HEAT INJURY TO TEA PLANTS.

In some tea districts of North East India, where the soil is of such a nature that it becomes very hot in the sun, tea seedlings on the southern side of the nursery beds and infills in unshaded areas wither and die for no apparent reason. The leaves usually turn brown and curl inwards. Sometimes a smear of sticky brown substance is seen on the undersurfaces of damaged leaves.

If the stem at the collar of the dead seedlings be scraped with a knife, an effect similar to that caused by *Phomopsis* sp., will sometimes be observed. But unlike the latter the discolouration of the stem is often confined to the southern aspect of the plants. The black lines and rings formed by the fungus in the wood of the affected portion are also absent in this case. Another important distinguishing factor between the two is that seedlings after 7 months from the time of germination are practically immune to the attacks of *Phomopsis* sp., whereas heat may injure plants even three years old.

Those plants which are not severely injured, subsequently develop a callus growth at the upper edge of the damaged area, similar to that following the removal of bark by other agencies. This callus in most cases covers one half to three fourths of the total circumference of the stem, although it is not unusual to find a callus forming all round it but in this case one side is noticeably less affected than the other (see pl. 9, fig. 3). The bark of the damaged area unlike that in case of insect damage remains intact in the early stages. The callus sometimes grows under the dead bark causing it to peel off.

TREATMENT.—Nurseries should be protected by shading with a flat shade about 5 ft. high. It should not be removed abruptly, but should be thinned out gradually.

Plants which develop callused rings at the collar should not be planted out. Some of these may live for years and even make a certain amount of growth but the chance of their becoming good yielding bushes are small.

## CHAPTER VI.

### *Organisms attacking dead tissues.*

*Aleurodiscus* Sp.

This fungus was formerly referred to as *Coritcium* Sp. 2 in the I. T. A. Quarterly Journals.

During the investigations on *Corticium dealbans* this fungus was frequenly found on dead twigs on the same bushes. The presence of the fungus can only be detected by its peculiar fructifications. These are small, chalky-white patches; usually $\frac{1}{8}$ to $\frac{1}{4}$ inch in diameter, almost round, occasionally elongated with abruptly raised margin (see pl 7, fig. 5). Sometimes several patches coalesce to form a big one. The spores are produced on basidia which are contained in the white patches.

It is purely saprophytic and it does not do any harm to the tea plant.

No treatment is necessary.

*Stilbum nanum*, Massee.

This is one of the commonest fungi associated with dead twigs of all kinds. It is found everywhere in North East India. It is purely saprophytic and it has not been observed to attack living tissues.

It does not produce any external mycelium but its fructifications are very obvious. These are small pinkish red, pin shaped projections, about 1 to $1\frac{1}{2}$ m. m. high, provided with a round, white top, produced in great numbers on the dead twigs. These resemble the conidial fructifications of Violet root rot (*Sphaerostilbe repens*) but the the latter are always produced on the roots while these are found only on the twigs above ground. Moreover these pin heads are much brighter in colour. The stalks remain standing for a long time even after the white tops drop off. Those of Violet root rot shrivel and drop off readily on drying. Some people confuse these pinheads with the fruiting heads of Red rust *(Cephaleuros parasiticus)* but the latter are very much smaller in size and are usually produced on living branches.

No treatment is necessary.

*Marasmius equicrinis*, Mull.

HORSE-HAIR BLIGHT.

This fungus is present in all tea districts. It originates on dead leaves and dead bits of stem, in fact any kind of debris that may be

lying in the centre of the tea bush—especially in the damp shady places. The fungus is called 'Horse-hair blight, as the mycelial threads form black, shining cords about the size of a horse-hair and also similar in appearance. These cords pass from one twig to another at random attaching themselves at different points to dead twigs and other material and also to the outer bark of the living stems. Ultimately a tangled mass resembling the combings from a horse's tail is formed. Occasionally where cords happen to grow out from opposite points on a living stem it would appear that a single cord has passed right through the stem and continued its growth on the other side. Actually the fungus never penetrates the living tissues, it is superficial. Now-a-days, as a result of improved cultural methods this fungus is rarely seen on tea bushes. It may be found on fallen leaves and twigs on the ground in a bamboo bari quite easily.

So far the fructifications of this fungus have not been found on tea in North East India.

TREATMENT.—The affected bushes should be cleared of all debris. No fungicidal treatment is necessary.

### *Nectria* spp.

Several undetermined species of *Nectria* have been found, from time to time, on dead tea and other wood. They are all saprophytic and, unlike *Nectria cinnabarina*, cannot attack living wood even through wounds. They also produce three different types of fructification, which, only differ microscopically from those of *Nectria cinnabarina*. There is a slight difference often in the colour of the spherical bodies (perithecia) but it is difficult even for an expert to tell the difference without microscopic examination. The occurrence of these saprophytic species is not confined to any particular part of the plant. They may sometimes be found on dead exposed roots. One species has been observed to grow freely on the fructification of Charcoal stump rot.

TREATMENT.—As it is impossible to distinguish these from *Nectria cinnabarina* without microscopic examination it is advisable to apply the same treatment as in the latter (see page 15).

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Note :—It may be mentioned that tea branches affected by *Nectria*, *Glomerella major* and similar fungi often show a greenish-bloom on the bark. A similar appearance sometimes follows spraying with Burgundy mixture. This green appearance is in all cases associated with the presence of a green alga. Any connection between this alga and the condition of the branches concerned has not been ascertained.

## CHAPTER VII.

### *Organisms grown on the surface—not known to penetrate living tissues.*

#### WHITE STEM BLIGHT.

This disease is known as White Stem blight as the affected tea stems are bleached white all over (see pl. 7, fig. 1). The fungus is almost similar in its effect to *Corticium dealbans*. There is however some difference between the two. *Corticium dealbans* is evident mostly on the one year old growth whereas White Stem blight may be seen on one to three years old branches. Stems affected by the former retain the shreds of brown primary cortex on their surface while in the latter the primary cortex is missing and the surface is quite smooth. Unlike *Corticium dealbans* it extends to the underside of the leaves. Sometimes it may be confused with Thread blight but differs from it in not having, thick, well defined, white cords. The mycelial strands of this fungus are very much smaller and the hyphae instead of running in a cord spread out in all directions on the surface of the stem. The hyphae are very fine and invisible to the naked eye. From the stems the fungus spreads to the under-surface of some of the leaves giving the diseased patch a silky, rather dull white appearance. This portion of the leaf looks yellowish green on the upper surface. When held against the light the affected portion presents a watery, somewhat translucent appearance. This is more evident immediately at the edge of the diseased area. On drying this portion becomes pale yellow and papery.

The disease does not spread to any appreciable extent and its progress is slow. So far it has not been observed to kill the branches concerned. The fungus is external and it is easily removed by fungicidal applications. A single application of strong Lime sulphur solution after pruning is sufficient to kill the fungus.

### *Marasmius pulcher* (B. & Br.) Petch.

### The Epiphytic Thread blight.

This Thread blight is almost similar in appearance to the parasitic form described in Chapter I. Unlike the other it forms fan-like films of mycelium on the older branches. On the leaves instead of forming a film of mycelium on the under surface it runs in the form of thin threads which apparently do not do any damage to the leaves. In North East India it is fairly common on tea and other plants. It is often seen on bushes in shady places between the small hills of the Surma Valley.

The fructification of the fungus has been described by Petch as follows. "The fungus sometimes forms broad, thin expansions at the side of the cord on the stem, and these become covered with minute white cups, about half a millimetre in diameter. Similarly, after a leaf has withered, the fungus may grow on into a film which covers the under surface of the leaf, and the same white cups may develop on the film. These cups are the fructifications, but not the fully developed form. The latter is found on leaves, which have fallen to the ground, or into the middle of the tea bush, and is a small, helmet-shaped basidiomycete, white above, ochraceous below, with a few gills on the lower surface."

TREATMENT.—As this is practically indistinguishable from the parasitic form, without careful examination, it should be treated as the latter. It is however quite harmless.

### Algae.

Algae are plants belonging to the same class as slimy, green, hair-like plants found mostly in stagnant pools and some of the

sea-weeds. They are mostly green but there are other colours as well. For instance Red rust algae is orange coloured and the green scum sometimes seen on the surface of stagnant water changes to brick red in the afternoon.

Greenish colouration or the slimy green appearance of old tea stems in damp places is a very common occurrence. This is due to the growth of an algae which cannot be discerned with the naked eye. Tea branches attacked by *Nectria cinnabarina* and *Glomerella major* also bear a greenish look although there seems to be no connection between these fungi and the greenish colouration. This is mistaken by some people as a result of spraying with Burgundy mixture but it is purely due to the growth of a microscopic algae.

So far none of the algae except the one causing Red rust have been known to be harmful to tea.

## Lichens.

Lichens are not individual plants but the result of the association of two kinds of plants—fungi and algae. For instance, in damp shady places old tea leaves may be observed to bear on their upper surfaces a number of grey spots. They are the result of the Red rust algae growing in co-operation with a black fungus thus forming something which looks like a different plant altogether. The spots may be rubbed off the surface without injuring the leaves.

Lichens are universally present on all trees and shrubs in the Tropics. They are of varying colours and texture. Some lichens grow flat on the surface of the stem and mostly look like thin painted patches; (pl. 1, L) others form irregular, thin, wrinkled, leaf-like sheets, lobed and curled at the edges or bunches of branched hairs. Most of the foliaceous type are greenish-blue to ashy-grey in colour and are attached to the surface of the stem at intervals. They are only common on tea in the hill districts. Where present these are easily pulled off the stem. The other, flat type, consists

of dull white, light to dark grey, green, yellowish, brick-red, blue or greenish black patches, some of which change colour and become brick red when they come in contact with an alkali such as Caustic soda. Except a very few, which are up to a millimetre in thickness, the rest are very thin. They adhere to the surface of the stem so closely that they appear to be part of the bark. The dark green patches are found mostly on the bigger branches lower down. Some patches are plain, others bear spots and marks of various designs such as small white or pinkish stars, dull white, pinkish or black irregular spots about $\frac{1}{4}$ inch across, straight or curved, irregular black lines about $\frac{1}{8}$ inch long, black points or pin-heads up to about a millimetre, small yellowish cup-shaped bodies etc. Most of these are fruits of the lichens.

Lichens are not parasitic on the tea bush but they may interfere with the growth of the plant to which they are attached by offering mechanical resistance to the expansion in circumference of the stems. The leaf like ones also harbour insect pests. Lichens are inevitably present on any tea bush but only to an injurious extent on bushes which owing to their poor condition make very slow growth.

In 1920, in the Report of the Department of Agriculture, Ceylon, two lichens are reported to cause stem galls of tea seed bearers. They are said to be very susceptible to lime.

TREATMENT.—Vigorous bushes do not require any treatment for lichens but the badly hide-bound ones should be painted with 1-2% Caustic soda solution after pruning. This will soften the bark and remove the lichens. Spraying with strong Lime sulphur solution will also be found effective. The hidebound bushes should be nursed back to good health by judicious manuring, plucking and pruning, etc.

Some lichens turn red or orange when they come in contact with alkali such as Caustic soda, Lime etc. This is sometimes mistaken for disease.

### Mosses.

Both in the plains districts and in the hills, especially at the higher elevations of Darjeeling, the tea branches develop mosses towards the base. These are superficial and not parasitic on tea. They sometimes serve as harbouring places for insect pests, otherwise they are harmless.

Mosses are found on all trees and shrubs growing in humid places.

TREATMENT.—These are easily rubbed off with a piece of sacking or a coarse husk. No other treatment is necessary.

## CHAPTER VIII.

### *Abnormalities.*

#### APPLE FOLIAGE BLIGHT.

This is a peculiar phenomenon sometimes observed on healthy tea bushes. Some of the branches instead of producing leaves of normal size and shape produce several thin, wiry shoots, from one point, with thin, miniature leaves about the size of a big 'janam'. Some of these leaves bear a few serrations towards the top end, others have a smooth edge. The whole bunch gives the appearance of a "witche's broom." The cause of this curious growth is not definitely known yet. Although "witche's broom" on other plants has been stated by some observers to be caused by fungus, the writers have not observed any such relation in case of Apple foliage blight on tea. It does not seem to spread.

#### ROSETTE BLIGHT.

This is also a curious growth of the branches quite different from the Apple foliage blight. In this case the shoots at the top of the branches are produced in their respective positions but these become abnormally thick, the internodes are very short and the leaves well proportionate but usually small. The nodes being very

closely situated the leaves are produced in a bunch. This gives a rosette appearance. The leaves towards the base of the main shoot may be normal.

A similar formation on pine has been stated, by Sorauer, to have resulted from local over-nutrition on trees which have previously suffered very great loss of foliage (usually from the attacks of caterpillar). In two cases of tea Rosette blight the writers have observed an eelworm (not *Heterodera marioni*) to be present on the shoots concerned. Whether this eelworm is responsible for the peculiar growth has not been proved. This disease does not appear to spread. Thrips sometimes produce similar effects but these are easily distinguishable.

### Fasciation.

This phenomenon is often noticed on succulent plants such as tomato but rare on woody plants like tea. The green shoot instead of being round and a few millimetres in diameter flattens out to a breadth of about ½ to 1 inch. The surface may be plane or ribbed appearing in the latter case as if several shoots have anastomosed sideways. Microscopic examination however shows that it is a single stem and not the result of coalescence of serveral shoots.

The cause of this curious formation is not definitely known. It is attributed by some observers to insect or fungal attacks, others think it to be due to local over-nutrition. So far no fungus or insect has been observed by the writers to be connected with such growth on tea.

### Zig-zag form of branch.

Some tea bushes have a tendency to develop zig-zag branches. Observations made by the Botanical Branch show that this character is definitely a bush characteristic. It is associated with very poor rooting capacity. It is interesting to note that in the course of the observations on the zig-zag character a high correlation was observed between it and a tendency to damage from "Rim blight". Gadd and

Bond in Ceylon have observed a correlation between bushes injured by Phloem necrosis and this zig-zag character. It should be noted however that no Phloem necrosis has been observed on tea bushes in North East India.

## Abnormal callus growth.

The term callus is applied to the overgrowth of bark and woody tissues, developed by a plant, in an attempt to repair injuries. On tea, as on other plants, abnormal callus formatiou is caused by a number of agencies such as fungus parasites, Red-rust alga, insect pests, sun-scorch, wind, hail and mechanical injuries. As a rule callus growth is more rapid on vigorous healthy bushes than on poor moribund ones and it looks brown. Callus formation caused by the different agencies as observed in North East India are as follows. Burrs are apparently formed sometimes by the suppressed growth of adventitious buds. This may be caused by insect attacks.

### (1) Fungi.

(a) *Nectria cinnabarina.*—When surface wounds on the bark of healthy branches caused by hail, slight cuts, bruises ete., are attacked by the fungus, it kills the bark tissues and extends to the growing layers (between the bark and the wood). A ring of callus forms at the outer edge of the affected lesion. This growth is arrested before proceeding very far as the fungus gradually spreads to the tissues concerned with its development. Such callosities appear as patches of dead bark surrounded by raised rings the edge of which seems to roll inwards. Often the dead bark cracks and peels off. On large branches such as those on shade trees ring after ring of callus forms and dies—thus forming a canker. On tea the branches concerned usually die back before a canker has formed.

(b) *Macrophoma theicola.*—Each of the sunken patches on hard tea branches caused by this fungus is almost invariably surrounded by a ring of callus. This is killed by the fungus before progressing very far and a new one is formed a little further away and thus a

second or even a third ring of callus is sometimes formed in succession (see pl. 4, fig. 4). On older branches the callus growth may be marked only by a slightly raised ring. The dead bark usually persists for a long time.

(c) *Hypoxylon asarcodes.*—Longitudinal patches of dead bark several inches long are surrounded by a ring of callus as in *Macrophoma*. Fructifications of the fungus resemble dried patches of black wound paint on the dead bark. The diseased bark does not peel off readily.

(d) *Phomopsis* sp., (Collar rot of seedlings)—Young seedlings slightly affected by the disease at the collar sometimes survive the attack and in an attempt to bridge the gap caused by the fungus a callus ring is formed on the stem about 1 to 1½ inch above the soil surface. The callus ring is formed beneath the bark and the latter is pushed up. The bark on the affected area persists for some time (see pl. 9, fig. 2.)

(e) *Rosellinia arcuata.*—Sometimes this fungus kills a ring of tissues at the collar extending to 3 or 4 inches in width. The host plant frequently forms callus growth at both ends of the diseased patch, and the general appearance suggests insect attack but closer examination shows that the bark has not been eaten off.

(f) *Corticium salmonicolor.*—This fungus kills the bark on the stem in patches. On vigorous bushes these patches are sometimes healed up completely by callus formation. On older branches the diseased patches, usually long and narrow, are surrounded by a slightly raised, thin ring of callus. As callus formation on older branches is rather slow the diseased tissues are invaded by other wood destroying fungi before the patches are completely healed up. As a result the wood rots and decays away leaving a hollow channel similar to that caused by sunscorch. The only difference is that the effect of this disease is not confined to any particular aspect of the bush.

For treatment see under the respective diseases.

### (2) Red rust alga.

As the algal cells penetrate the bark the cells of the host plant die in advance of the invading alga. Sometimes the algal cells succeed in penetrating one layer of dead cells but another layer forms ahead. Meantime callus forms ahead of the dead layer thus when the parasite reaches the growing layer the plant has developed a ring of callus, on the smaller patches. The callus beneath the affected tissues pushes them up. The twigs concerned acquire an irregularly swollen appearance. The surface of the swellings frequently bears longitudinal cracks.

Treatment.—See page 48.

### (3) Animal parasites.

(a) Cockchafer grubs—About 1 inch of the bark at the collar of young plants in the nursery or young infills may be eaten away in a ring, usually right down to the wood, by cockchafer grubs. A ring of callus is formed at the edge of the exposed wood (see pl. 9, fig. 1). The absence of the bark helps to distinguish it from similar callus formations caused by fungi. Examination with a lens frequently reveals the cut marks made by the parasites concerned.

(b) Tea Mosquito—Young green stems punctured by tea mosquito during the rains sometimes develop swollen patches later on. The bark on these patches cracks owing to the pressure of the callus forming below it (see pl. 11, fig. 2). The surface of the callused area is irregular and the stem in such places attains a girth up to about 3 times that of the adjoining unaffected portion.

(c) Cachar stalk killing mite—Callus formation similar in appearance to that caused by tea mosquito is also produced by mites especially in the Surma Valley.

(d) Scale insects—Irregular swelling of the branches may be caused by a prolonged attack of this insect (see pl. 11, fig. 1).

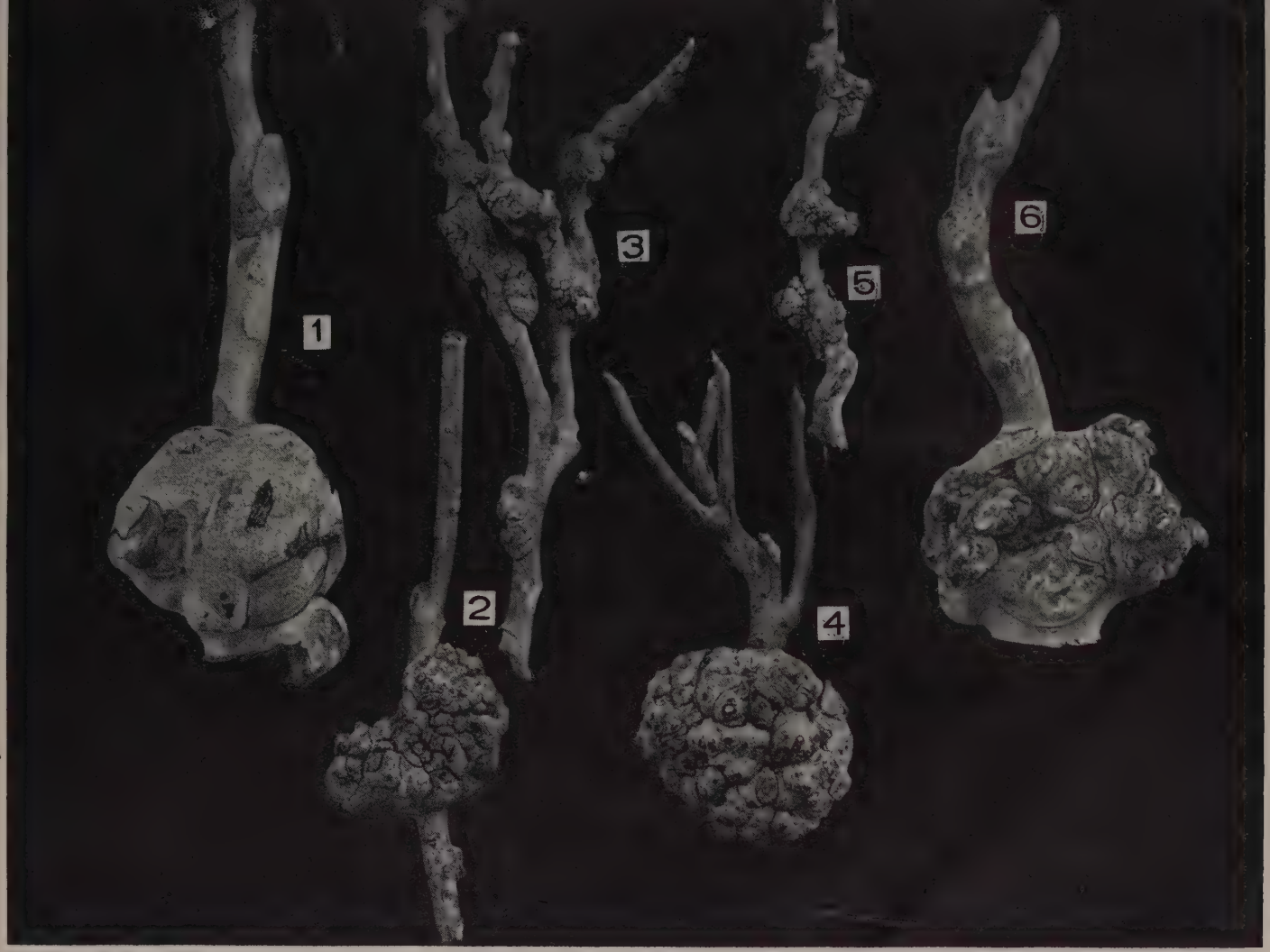
(e) Other animal parasites—Various other animal parasites are responsible for several forms of callus growth but their identity remains unknown as they disappear soon after doing the damage. These forms include (1) hard lumps or burrs, with irregular surfaces, varying from half an inch to six inches in diameter (see pl. 10, figs. 2—5), (2) Smooth woody galls or lumps up to about 10 inches or more in diameter (see pl. 10, figs. 1 & 6), (3) irregular swollen patches as in (b) and (c) (see pl. 11, figs. 2 & 3) and (4) hollow wounds with a ring of callus at the edge.

TREATMENT.—Callus growths with irregular surfaces and unusually large size are best removed as they serve as harbouring places for various insects and fungi. Moreover, along with the increase in size they use up a lot of nourishment which will otherwise be available to the rest of the branch concerned.

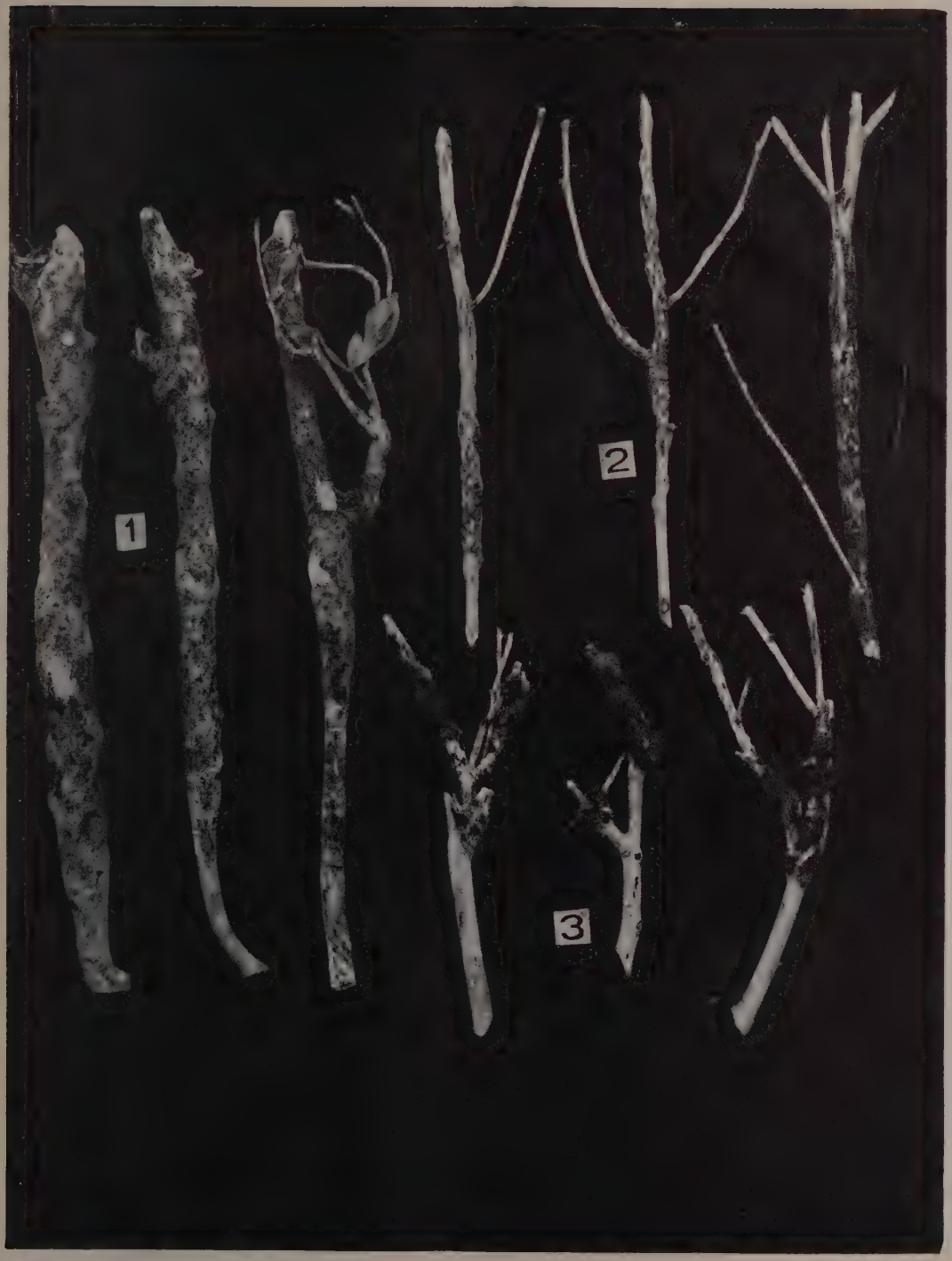
### (4) CLIMATIC CONDITIONS.

(a) Hail—Cuts made by hail always develop rings of callus at their edges. On vigorous bushes the cuts are completely sealed up by callus growth within a reasonable time. Occasionally some of them become infected by fungi such as *Nectria cinnabarina*, *Macrophoma theicola* etc., before they are sealed up and the progress of the callus growth is arrested. Callus growth due to hail injury always occurs on the upper surface of the branches. The bark of the injured patch is usually missing.

(b) Wind—High wind sometimes causes one stem to rub against another so that the brak is damaged by the friction. Callus formation takes place on both the stems and sometimes they join. Hot dry wind sometimes dries up the bark on the side of exposed bushes. The bark then falls prey to various fungi. The severest change by this agency is caused at places where a young branch emerges from a larger stem. The bark round the base of the branch and sometimes on the side of the parent stem opposite to the base of the branch dries up. Callus then grows round the dead bark.




(1) & (6) Galls of unknown origin (2) & (4) Burrs probably of insect origin
(3) & (5) Callosities probably caused by eelworms.




(1) Swellings on tea branches following a severe attack of scale insects, (2) Callosities following an attack of tea mosquito (3) Callosities following insect attack—probably mites.

(c) Sun-scorch—The effect of sun-scorch, as regards callus formation, on branches is similar to that caused by *Macrophoma* but unlike the latter it is evident only on the stouter branches on the southern or the south-western aspects of the bush. The bark begins to peel off within a few weeks of the damage occurring and a bare patch of wood may extend from the top of the branch down to the soil level (see pl. 8). The damaged area does not callus over very rapidly. A further description of sun-scorch is given on page 50.

(d) Heat—Excessive heat causes the death of the cells at the collar of young plants. Callus forms on the stem a few inches above the soil level (see pl. 9, fig. 3). It is similar in appearance to that caused by Collar-rot fungus on young seedlings. The only distinguishable factor is that heat injury usually occurs on the southern edge of unshaded nursery beds and on young infills exposed to hot scorching sun. The effect of the fungus is evident on young seedlings less than a year old and it may be distributed all over the nursery and on any aspect of the plant.

Treatment.—The treatment should be adopted according to the requirements in each individual case. For example slight damage by hail on vigorous tea is likely to be repaired in a short time by the bushes themselves without any treatment whereas it may be necessary to protect the wounds by spraying them immediately if the damage happens to be heavy and in a locality known to be affected by *Nectria cinnabarina*. Similarly cutting out of the branches badly affected by sun-scorch, may be necessary in a few cases. Young plants likely to be damaged by heat should not be subjected to undue exposure to the sun by pruning in the growing season except under shade.

### (5) Mechanical injury.

(a) Pruning—Sooner or later callus formation takes place on all pruning cuts on vigorous bushes. It grows from the sides of the cut and usually joins at the centre sealing the cut completely. Sometimes the thin flat plates of callus instead of fusing in the

centre grow over one another, particularly in the case of cuts on the older wood. Cuts on older wood often take a long time to heal and if the exposed wood is not protected fungi may attack it and rotting sets in before healing is complete. Callus surfaces on pruning cuts are generally smooth.

(b) Plucking—Occasionally small lumps of callus form at the end of plucking shoots.

(c) Artificial ringing of young plants—In some places young plants of about three years are artificially ringed by removing a ring of bark about 3 inches wide at the collar with the idea of inducing branch development lower down. Such plants develop callus growth simillar to that following damage by bark eating insects, rats and other agencies which remove the bark.

TREATMENT.—Large pruning cuts should be smoothed and painted with a bituminous mixture and the painting repeated at each pruning until the healing is complete.

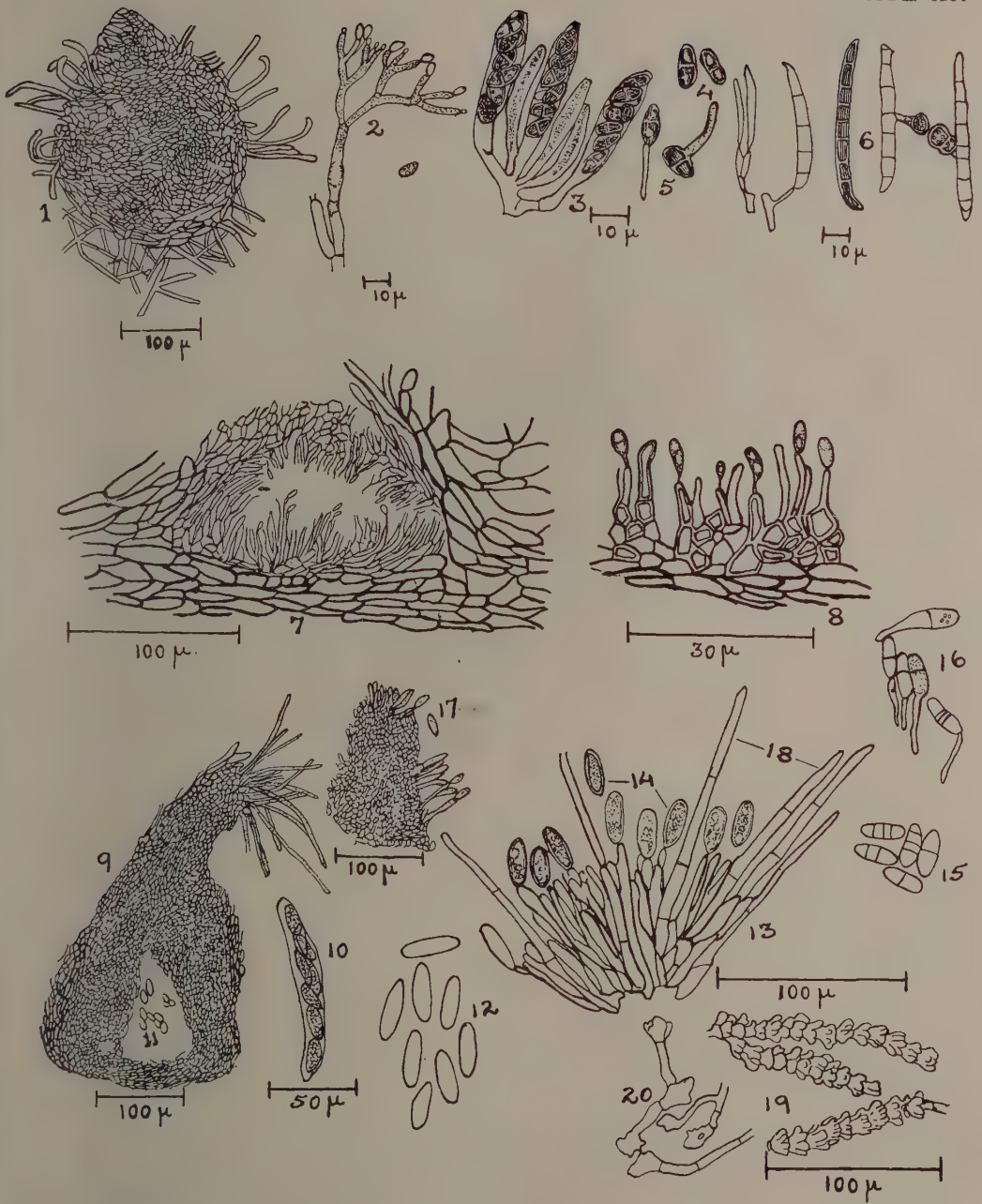
Artficial ringing of plants should be avoided. Plants with a callus ring on the main stem, at or above the soil surface are better replaced as soon as possible. Such plants may continue to live but they will never make good, paying, bushes.

## CHAPTER IX

### *Mycological Notes.*

ASCOMYCETES.

*Nectria cinnabarina.*—Perithecia arise singly or in groups on the bark, usually in cracks and fissures or in leaf scars, occasionally arise from conidiophores, otherwise on a stroma, usually cushion shaped, dark red, becoming brown or slightly blackened with age, almost spherical, with a conical, light coloured ostiole, protected by hairs often covered with minute granulations, about 200-400 microns in diameter.




Figs. 1-6. *Nectria cinnabarina* (Tode) Fr.,

(1) *Perithecium,* (2) A branched conidiophore with conidia, (3) Asci, (4) *Ascospores,* (5) Germinating ascospores, (6) *Fusarium spores.*

Figs. 7 and 8. *Phomopsis sp.,* (Collar rot of seedlings).

(7) Section of *pycnidium,* (8) Phoma type of pycnospores.

Figs. 9-20. *Glomerella major.*

(9) Perithecium with spinose dotted or warted hairs on the top, (10) Ascus, (11) and (12) Ascospores, (13) Colletotrichum form of fructification, (14) Conidia, (15) Conidia before germination, (16) Germinating conidia, (17) Conidia produced on the top of a perithecium, (18) Setae, (19) Appressoria from culture, (20) Appressoria from a tea stem.

Asci cylindrical or club shaped, slightly attenuated at the apex, 8 spored, about 47-65·7 microns by 11 microns.

Ascospores usually biseriate in the ascus, oblong, slightly curved, one-septate, hyaline, minutely striated longitudinally, about 10-15 microns by 5 microns.

Conidiophores hyaline, pink in mass, usually branched, produced in masses which look like small cushions.

Conidiospores hyaline, oval, continuous, about 7·5-10 microns by 3-3·75 microns.

Fusarium spores are formed in the neighbourhood of both perithecia and conidial cushions; these are hyaline, 4—11 septate and about 37-60 microns by 3-3·5 microns.

*Glomerella major*—mycelium colourless at first, changing with age to very dark brown.

*Colletotrichum* form

Conidia, mean 24·8×7·7 microns, range 14·4—30·6×4·8—9·6 microns, 1—3 septate at germination, mostly cylindric with rounded ends, occasionally slightly curved; rarely attenuate at one end; finely granular contents; clear spot sometimes present at or near the middle.

Conidiophores simple, or branched with brown walls; 2-3 septate; clavate; about double the length of the spores; apical enlarged cell 6—8·5 microns in diameter. Setae 100—200×4·5-5 microns, brown to opaque-brown, up to 4 septate, subacute, of uniform tint.

*Glomerella* form

Perithecia very variable; diameter 130—150 microns; beaked ostioles commonly present with or without an apical tuft of brown hairs, sometimes spinose, dotted or warted; beaks, when present, cylindric or subconical, up to 160×100 microns; opaque black

walls up to 50 microns; developed in a stroma beneath periderm, either remaining immersed or becoming erumpent with beaked ostiole.

Asci clearly defined only when immature; when mature about 70—110 × 10—18 microns; paraphyses not present.

Ascospores usually 8 in ascus, elliptic with obtuse or subacute tips; frequently slightly ineqilateral; not allantoid; clear spot at the middle; mean 24·9 × 7 microns, range 15·6—30·1 × 5·5—8·4 microns; walls usually become brown when released into perithecial cavity; germination sometimes occurs in the cavity, the spores becoming 1—2 septate, rarely 3 septate.

*Gibberella* sp.,—Perithecia—Mostly globose, light violet coloured, papillate, about 180 microns across.

Asci—clavate, 8 spored (spores biseriate in the ascus), about 47·5—75 microns × 11—14 microns.

Ascospores—Fusiform, ends tapering—almost pointed, 4 celled, hyaline, 15—25·6 microns × 3—4 microns.

Paraphyses—None.

Fusarium spores—Hyaline, up to 6 septate, about 16·7—40 microns by 2—3·6 microns (average 30·5 × 3 microns).

*Aglaospora sp.*
*Hypoxylon asarcodes*
*Ustulina zonata*
*Rosellinia arcuata*
*Sphaerostilbe repens*

Descriptions of the fructifications of these fungi have been published in I. T. A. Memorandum No. 8—Notes on Root Diseases.

SPHAEROPSIDEAE.

*Macrophoma theicola*—Pycnidia black. thinwalled, immersed, occurring in large numbers, scattered, measuring with ostiole 150—270 microns × 120—208 microns.

Pycnospores—Long, straight or fusoid, lanceolate, one end truncate and the other obtuse, hyaline, continuous, 23—38 microns × 4·8—7·2 microns (average 28·8×5·3 microns).

*Phomopsis* sp.—(Collar rot of seedlings) Pycnidia—Locular, very variable in size and shape, at first subepidermal later erumpent, usually with a broad base, produced in a thin stroma.

Conidiophores—Crowded, rarely branched, pointed, hyaline, occasionally septate (sparsely) at the base, up to 19×2·4 microns.

Spores—A (Phoma) type—Oblong, straight, continuous, hyaline, biguttulate, about 3·6—8·3 microns × 1·6–2·4 microns (average 5·8 × 2 microns).

B type (scolecospores)—Filiform, continuous, hyaline, uncinate, 12—33·5×1 microns (average 23·5×1 microns).

*Aschersonia* sp., —Mycelium—Thick-walled, hyaline, septate, irregular, about 7·2 microns across.

Pycnidia—Embedded in a pulvinate stroma, irregular in shape, without any distinct wall—the conidiophores arising directly from the stroma. They measure about 280—655 microns × 185—445 microns (average 470 × 305 microns).

Conidiophores—slender, single or branched, continuous, hyaline, 21·5—60 microns × 1·2 microns.

Pycnospores—Hyaline, fusoid, continuous about 6—16·7 microns ×1·7–3·6 microns (average 11·3×2·6 microns).

*Botryodiplodia theobromae*—Descriptions of fructifications have been published in I. T. A. Memorandum No. 8.

## Basidiomycetes.

*Septobasidium bogoriense*, Pat.—Boedijn and Steinmann give the following descriptions :—

"On the exterior hyphae the probasidia are born. They originate sideways, are sitting or shortly stalked, globose and colourless, the wall slightly thicker than that of the supporting thread, and

measuring 6—9 microns in diameter. From the probasidia the basidia germinate. These are thin-walled, colourless, at first straight, and later on curved, and 4 celled. They measure 25—34 × 4—5 microns. From each cell, a sterigma can originate, whereon the spores are born. Spores hyaline, mostly elongated cylindrical, with slightly tapering ends, straight or slightly curved, 11—16 microns × 2—3 microns."

*Corticium dealbans*, sp.—Nov. (Formerly mentioned as *Corticium* sp. 1.)—The fructifications are pinkish patches ½ inch to 1½ inches long and ⅛—⅜ inch across.

Basidia up to about 11 microns by 8·7 microns; sterigmata, 2—4 in number and measure up to 6·5 microns by 2·2 microns.

Basidiospores, broadly elliptical or oblong, hyaline, continuous, 7·8—11·7 microns by 4·3—6 microns.

*Aleurodiscus* sp.—Fructifications are small, chalky-white patches, almost round, with raised margin, about ⅛ inch to ¼ inch across.

Basidia measure up to 21 microns by 11 microns.

Sterigmata, usually 4, up to 11 microns long.

Basidiospores, oval, hyaline, continuous, about 10·8 microns by 8·7 microns.

*Corticium salmonicolor* (B & Br.)—Petch describes as follows:—

"Thin, effused, frequently surrounding stems and branches for a considerable distance, rose-pink or ochraceous, minutely pulverulent, finally cracked and aerolated, basidia clavate, tetrasporus; sterigmata slender, 4—6 microns long; spores pyriform hyaline, apiculate, 9—12 microns × 6—7 microns.

*Auricularia Auricula-Judiae*
*Fomes lignosus*
*Fomes lucidus*
*Helicobasidium compactum*
*Poria hypobrunnea*

} Descriptions of the fructifications of these diseases have been published in I. T. A. Memorandum No. 8—Notes on Root Diseases.

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